KNOWLEDGE
AN ILLUSTRATED
MAGAZINE OF SCIENCE
SIMPLY WORDED—EXACTLY DESCRIBED

LONDON: NOVEMBER 1, 1892.

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THE DISASTER AT ST. GERVAIS.

By the Right Hon. Sir EDWARD FRY, LL.D., F.R.S.

WHILST at Chamonix this summer I was much interested in obtaining the best information which I could as to the physical causes of the destruction of the baths of St. Gervais, which excited such a widespread interest and sympathy. I had the advantage of studying with M. J. Tairraz, photographer of Chamonix, the photographs which he had taken the day after the event, and of conversing with M. Venance Payot, who was also on the spot about the same time, and with one or two other persons who visited the site somewhat later. From this information, and from what I myself saw, I was able to come to a pretty clear view of what had happened. Since my return to England I have studied the very interesting paper on this subject by M. Vallot, the director of the Mont Blanc Observatory (who visited the spot on the 19th July), which appeared in *La Nature* of the 20th August, as well as the note signed "D. W. F." in the "Proceedings of the Royal Geographical Society" for August, and the numbers of the *Times* newspaper and of *Nature* which contained information or correspondence on the subject.

In the hope that what has so much interested myself may interest some of the readers of KNOWLEDGE, I have written this paper, with the view of endeavouring to give some account of the causes of the catastrophe, not of giving any detailed account of the event itself. Fig. 1 shows the baths of St. Gervais before the disaster; Fig. 2 shows their remains after it. A comparison of these two views will sufficiently bring to the mind the nature of the destruction caused by the event. These views, like all the others which illustrate this paper, are after photographs taken by M. Tairraz.

The accompanying sketch map (Fig. 3) will enable the reader to follow the narration of this terrible disaster. The western slopes of Mont Blanc (the summit of which lies beyond the south-east corner of the map) descend into the valley of the stream known as the Bon Nant, which, rising in the Col du Bonhomme, runs nearly due north. The well-known heights of the Dôme du Gouter and the Aiguille du Gouter give off glaciers which, through tributary valleys, send their waters into the Bon Nant, and amongst these the glacier de Bionnassay. Above this glacier to the north are found glaciers called the glacier de la Gria and the glacier des Têtes Rousses. The stream from the Bionnassay glacier will be seen to flow below the village of Bionnassay, and close to the village of Bionnay to join the stream of the Bon Nant. This continues to flow northward till about half-a-mile above St. Gervais it enters a narrow and deep gorge. Just where this gorge opens out, the baths of St. Gervais were built across the valley—there about 100 feet in width. From the baths, the Bon Nant continues its course northward till it joins the Arve, near the village of Le Fayet. The gradients of this piece of country are steep. The Aiguille du Gouter is 12,710 feet high above the sea-level, the Têtes Rousses about 9000 feet, the baths 2060 feet, and Le Fayet 1950 feet. Such is the general character of the locality.

Early in the morning of Tuesday the 12th July last, a terrible volume of water, ice and mud overwhelmed the baths and destroyed many lives.

The source of this calamity is to be found high up in the glacier des Têtes Rousses.

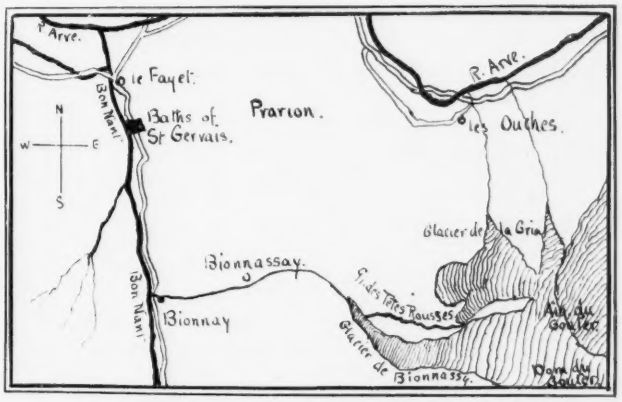

FIG. 3.—Sketch Map of district surrounding St. Gervais.

The enlarged sketch map (Fig. 4) will enable my readers to understand the locality more exactly. The large glacier marked A is the glacier de Bionnassay; the glacier immediately to the north of it, and marked B, is the glacier des Têtes Rousses; C is the glacier de la Gria. The upper part of the glacier des Têtes Rousses is nearly a plateau, and is confined, to the south, by rocks which divide it from the glacier de Bionnassay, and partially to the west by the rocks of Têtes Rousses, E F.

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Between E and F the glacier des Têtes Rousses falls rapidly by a steep incline of something like 45°.

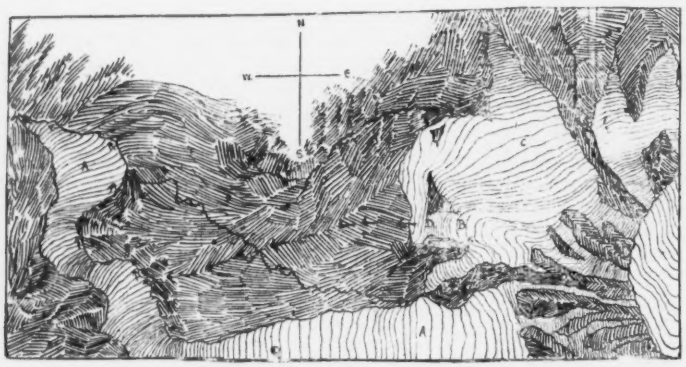

Fig. 4.—Sketch Map of Glacier des Têtes Rousses and Surroundings. A, Glacier de Bionnassay; B, Glacier des Têtes Rousses; C, Glacier de la Gria; D, lower cavity; E. F, Rocks of the Têtes Rousses.

On the plateau of the Têtes Rousses glacier, near where the letter B appears on the plan, there was formed in the glacier a great cavity filled with water, a glacial lake: it was probably entirely sub-glacial, *i.e.*, no part of the water was visible on the surface. Whether anyone had passed over or near this part of the glacier this year, before the catastrophe, seems doubtful, but last year no one had noticed the existence there of any lake. This cavity was about 260 feet by 130 feet in superficial extent, and had a vertical depth variously estimated from 130 to 160 feet. This cavity communicated by a passage through the ice with another cavity situated in the sharply inclined part of the glacier, and at or near the spot marked D on the map (Fig. 4).

Neither of the cavities disclosed the rocky floor of the glacier; the floor both of the passage and of the upper cavity was formed of broken masses of ice which had fallen in. Whether the solid ice of the glacier or the rock lay immediately beneath these broken bits was not apparent. M. Tairraz believed the entire system of cavities to be in the substance of the ice.

M. Vallot describes the lower hole as having a diameter of 40 metres, or about 130 feet, and a depth of 20 metres, or about 65 feet. M. Tairraz described it as much shallower. M. Vallot describes the passage as having a length a little over 50 metres, or from 160 to 170 feet, whilst M. Tairraz estimated its length at nearly twice as much.

M. Tairraz, who visited the spot the day after the accident, and M. Vallot and his party, who visited it on the 19th of July, all passed from one hole to the other through the passage, though not without difficulty from the masses of ice which had fallen in from the roof.

Fig. 5 shows the upper of the two cavities. It will be observed that the roof fell in without any disturbance of the surrounding glacier.

Fig. 6 shows the lower of the two cavities, the cavity on the incline. From this cavity ramifying passages were observed by M. Vallot, and may have led to other reservoirs of water. Near this cavity the glacier has been strangely changed by the event. The ancient level of the glacier was continuous with the upper line on the horizon; the event has destroyed this continuity, and has set free a vast mass of ice which has slidden away and disappeared, leaving behind the great ice cliff which appears in the drawing, which is some 130 feet in height, and which stretches in a crescent form the whole way across the glacier between the points E and F on our last map.

Fresh snow fell almost immediately after the event, and is seen on the lower part of the picture. It wiped out all traces of the disruption on the new surface of the glacier. But both in the cavity itself and on the newly-formed ice cliffs are apparent the lines which indicate the divisions between the layers of ice formed in successive years.

Towards the bottom of the hole will be observed a cave-like hollow, which is the commencement of the sub-glacial passage to the upper cavity.

The imaginary section which forms Fig. 7 will perhaps help further to explain the situation. A is the upper cavity with its roof yet intact, B is the sub-glacial passage, and C the lower cavity. The dotted line will indicate and bound the mass of ice which was detached by the accident. The horizontal lines indicate water, and the oblique lines rock.

What seems to have happened was this: that on the morning in question the roof of the upper cavity fell in with a momentum which was sufficient to drive the water violently through the passage and into the lower cavity. In this cavity the upward pressure of the water was sufficient to detach the superincumbent mass of ice and to set it rolling rapidly down the incline. The roof of the upper cavity must have operated like the plunger of a piston and produced a sudden and intense pressure throughout the whole water cavities. The ice, being less thick above the second cavity than above the passage, yielded, and in its turn operated by suction on the water in the cavity and drew it after it. I suppose that the sudden slipping away of a great mass of ice would tend to produce a vacuum, which operating on the lower hole drew

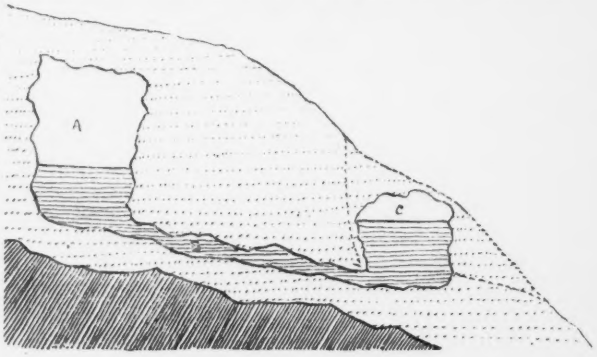

Fig. 7.—Imaginary section of the two cavities, with connecting passage. A, upper cavity; B, passage; C, lower cavity.

the whole contents out of it and of the adjoining cavities. In this way only can I account for the vast mass of water which formed part of the descending mass, and for the fact that on the day after the accident the two cavities appear to have been empty of water. It seems to me probable, as I shall hereafter mention, that the ice above the lower cavity was more or less loosened by crevasses running across the line of motion of the glacier and therefore in the same line as the cliff left by the departed mass of glacier.

The mass of ice and water thus set free slid over the steep glacier or nevé to the west, and then turned in a

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Fig. 6.—The Lower Cavity in the Tetes Rousses Glacier.

Fig. 5.—Plateau of the Tetes Rousses Glacier, showing the Upper Cavity, the roof of which fell in on the morning of Tuesday, the 12th of July, 1892, causing the Disaster at St. Gervais.

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south-westerly direction down a fold of the hills which crosses from the glaciers in question to the glacier de Bionnassay; when it reached the side of this glacier it impinged on the lateral moraine, but was driven back by this against an older moraine which it scooped out into a great cirque. These moraines yielded to the impetus of the moving mass of water and ice, and joined in the mad race which the rushing mass now pursued down the valley between the older lateral moraine and the present lateral moraine, until it reached the bottom of the Bionnassay glacier, near which it joined the stream from that glacier, and thenceforward travelled in its course, overturning first a châlet in the wood, where were an old woman and some cows: then leaving the village of Bionnassay safe on its height above the stream it passed downward to Bionnay, which it almost entirely destroyed, joined the course of the Bon Nant and rose as the gorge narrowed to a great height, from which it fell with remorseless energy on the doomed baths of St. Gervais. Thence it continued its course through the beautiful grounds of the establishment till it reached the junction of the Bon Nant and the Arve, at Le Fayet, where it spread out into a horrid flood, that is now represented by a great expanse of grey mud and sand and wreckage, extending far and wide over what was before a populous and fertile stretch of country.

The course of the avalanche as above described is traced on the second sketch map by arrows which indicate its direction. It may in like manner be traced on Figs. 8 and 9. Fig. 8 is a general view of this part of the mountain range taken from Prarion, north-west of the glacier des Tetês Rousses; and Fig. 9 is a key to Fig. 8, indicating the course of the torrent by arrows.

Some notion of the momentum of the moving mass of ice, mud, and water may be gained not only from the destruction of the buildings at the baths of St. Gervais, but from the movement of great stones, or rather rocks, which it effected. One in particular, of vast dimensions, is shown on the right hand of Fig. 10. The villagers of Bionnay were intending to celebrate a *fête* on the 14th July, and with a view to letting off *feux de joie* on that occasion holes had been bored in a stone then in the village. That stone, with its holes, is now at St. Gervais, and was probably highly effective in the destruction of the baths. It is rather a rock than a stone. It is further stated that the iron safe in the office of the baths was carried five miles down the stream to Sallanches, where it was found (*Times*, 15th July, 1892). These facts are of great interest, as the power of water to move great masses of stone for long distances has been a moot point amongst geologists and students of glaciers.

This explanation leaves many things unexplained. Under what circumstances will water accumulate as water in the body of a glacier? What, in this particular case, caused the two great cavities and the communicating passage? Were they formed by some blocking up of "moulins," or "glacier wells," as suggested by Mr. Justice Wills in his letter to the *Times* (16th July, 1892), or "originally caused by sub-glacial collapse" as suggested by Mr. Von Lindenfeld in *Nature* (15th September, 1892)? [See also the letter of M. Delebecque in *Nature* of the 22nd September, 1892.] How did the falling roof of the upper hole acquire sufficient momentum to do all the work that it did? Was its weight augmented by some mass of snow or ice that fell suddenly upon it from above? Was the water in the cavities adequate to carry down the vast mass of matter which descended? or was it increased from water stored in crevasses which have disappeared with the fall of the glacier? or was ice reduced into water by friction in the downward rush of the mass (as Prof. Forel would have us believe)? Was the impact of the water the sole cause of the detachment of the glacial mass, or was there some rent in the glacier existing before the water operated which predisposed the glacier to break up under any blow which it might receive? Was the draught produced by the sudden slip of the glacier sufficient to evacuate the two holes of their fluid contents, or was there some other co-operating cause? Lastly, is the account above given in error in suggesting that the roof of the upper cavity was the first thing to move? or was it, on the contrary, the glacier on the slope which gave the initial motion, and did the roof of the upper cavity only yield to the suction produced by the sliding ice? These questions I can ask, but I cannot answer.

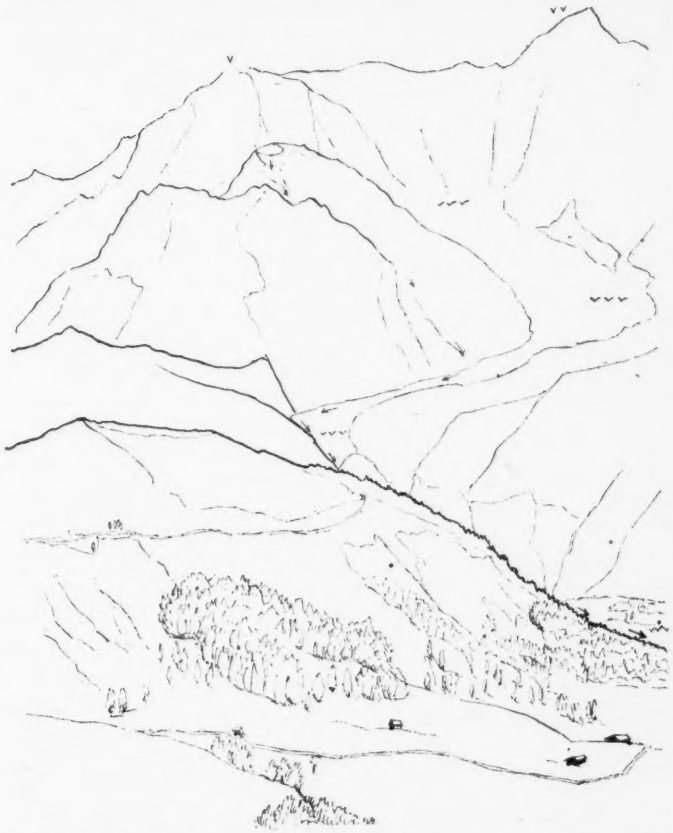

Fig. 9.—v Aiguille du Gouter. vv Aiguille de Bionnassay. vvv Glacier de Bionnassay. The arrows indicate the course of the torrent.

I have suggested that it is probable that the slip of ice was due to two causes—the one, an accumulation of snow and ice, so great as to cause a fracture on the slope, and the other, the action of the water on this unstable mass.

As regards the first of these causes, the facts in reference to the glaciers of Mont Blanc are in favour of it. It is well known that for some years past these glaciers have been on the increase, that the balance of deposition and waste is now in favour of deposition, and not as it was

for many years before in favour of waste. The glacier of Argentieres has been observed to have increased during the last few years in length, height, and width. The Mer de Glace is recovering some of its lost ground and, one may add, some of its lost beauty; the glacier de Bossons is advancing and overturning many of the sapling spruces which, in the period of its retreat, have imprudently ventured to grow on its moraines; and the like phenomena have been observed in other parts of the Alps.

As regards the outburst of water from the glaciers, it may be worth while to mention an event of the same kind, though on a much smaller scale, which has since occurred on another flank of Mont Blanc. On the eastern side of the glacier de Bossons, high up and very nearly under the Pierre Pointue, a stream flows from the glacier and rushes down the mountain side in a wide channel, of which in ordinary times it occupies only a small part. About ten o'clock in the morning of the 11th August a sudden outburst of water took place at this spot, and rushed as a muddy torrent down the water-course, carrying with it great stones, masses of ice and trees, destroying the bridge which crossed the stream, and at one spot breaking over the high bed of the stream and finding a new course for itself through the forest. At the time I was going up the Brevent and I heard the great roar of the torrent, and some of my party saw it descend. The next day I visited the spot where it had flowed over the bank, and found the forest there strewn with trees, torn up or snapped off, with blocks of stones of cubic dimensions to be measured by feet or yards, with blocks of ice and a layer of mud and sand. Many trees which had withstood the onset of the flood had been stripped of every twig, every leaf, and every particle of bark. On the trees which stood on the high bank above the stream, the flood had left a coating of mud as high as I could reach.

Both the St. Gervais outbreak of water and this on the glacier de Bossons occurred before the greatest heat of the summer that has just passed had set in.

It has been suggested that a part of the water which came down upon St. Gervais may have been due to the mass of ice forming a dam and so accumulating the water of a stream till it rose to such a volume as to burst through the dam. But the facts, so far as I can gather them, do not favour this suggestion. No one appears to have seen such a dam, or to have seen any trace of it after the event. No stream would seem likely to have been so dammed except that from the Bionnassay glacier. There seems to be no doubt but that the châlet near the foot of the glacier was destroyed on the same night as the baths of St. Gervais.

I am indebted to Monsieur J. Tairraz for permission to use, for the purpose of the engravings which illustrate this paper, some of the very interesting series of photographs illustrative of the event which were taken by him, and which are well worth the attention of all who are interested in such matters. I am further indebted to him for a great deal of information most freely and clearly communicated both by word of mouth and by letter.

CATERPILLARS.—I.

By E. A. Butler.

BY their frequently attractive colours, the ease with which most of them may be reared, the startling nature of the changes they undergo, and the great beauty of the resulting perfect insects, the larvæ of Lepidoptera have long since made themselves general favourites. Childhood's first essays in the direction of practical natural history often consist, to the more or less serious detriment of the comfort of the household, and the neglect of nursery proprieties, of the pastime of "keeping caterpillars," while the zealous work of manhood's maturer years may be given, as in the case of the late Mr. Buckler, to the delineation of their forms and the unravelling of their life-history. They sometimes force themselves unpleasantly on the notice of the community by the violence they do to agricultural interests or to æsthetic sensibilities, when they multiply to such an extent as to cause either great destruction or at least unsightly disfigurement of cherished objects of culture in the field or garden. They have sometimes proved so great a pest as to have earned for themselves a place in the records of history, and their name has become proverbial as that of a national scourge. In the days of mediæval superstition, when the animal creation was supposed to have its duties and responsibilities to humanity as well as humanity to it, caterpillars, along with other destructive creatures, were made the subjects of lawsuits and cited as defendants in the civil and ecclesiastical courts, where the penalties of the law were solemnly pronounced against them, and the curses of the Church and the terrors of excommunication held over them if they did not leave the district within a specified time. At such trials the accused were not always represented by proxy, but were sometimes caused to appear in their own persons before the judges; thus in 1451, during a plague of leeches in Switzerland, the Bishop of Lausanne suggested the advisability of procuring some of the aquatic worms and placing them before the magistrates. This was done, and they were ordered to leave the district in three days on pain of falling under the ban of the Church! In more modern days, on the other hand, caterpillars have become the handmaids of science by reason of their ready adaptability to observation and experiment; not only has their anatomy been duly investigated, but in connection with their peculiarities of form, colour, and markings, they have formed, and are still forming, the subjects of researches which may be expected to throw much light on several fascinating biological questions. If it be asked, for instance, why caterpillars are coloured and shaped as they are, it is not nowadays considered a sufficient reply to say that Nature is prodigal of beauty, but even the minutest peculiarities of marking and form are eagerly scrutinized and compared, in the hope of discovering facts bearing upon the pedigree of the creatures, or the influence of their environment upon them.

A caterpillar's life is not a very eventful one. The daily programme is rather monotonous, consisting of alternations of eating and ceasing to eat, and as a provident mother has usually placed it in such a position that it is from its earliest hours surrounded with abundance of food of the proper sort, there is little call for the exercise of any superior intelligence in satisfying the somewhat imperious demands of the periodically recurring hunger. But uneventful though on the whole it is, there are moments of excitement which cause its long thin-walled heart to beat more rapidly beneath its back, and its watery-looking blood to course through its body with greater vigour than usual. There is first, for example, the act of hatching. The walls of the often prettily ornamented little eggshell are nibbled through, and a big-headed but otherwise rather worm-like creature issues from the opening, prepared to make an immediate onslaught on the provisions in its neighbourhood. The amount of eggshell eaten in accomplishing this deliverance varies in different cases, the caterpillar being sometimes satisfied with making a hole just big enough to escape through; but, on the other hand,

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Fig. 8.—The Aiguille du Gouter and the Glacier de Bionnassay, down which the Torrent rushed.

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Fig. 2.—The Baths of St. Gervais after the Disaster.

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Fig 10.—Great Boulder moved by the Torrent from the Village of Bionnassay.

Fig. 8.—The Aiguille du Gouter and the Glacier de Bionnassay, down which the Torrent rushed.

Fig. 1.—The Baths of St. Gervais before the Disaster.

Fig. 2.—The Baths of St. Gervais after the Disaster.

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sometimes the entire shell is devoured at the first meal. Almost the only regularly recurring excitement is that of changing the skin, a process which may take place some five or six times, the exact number depending upon the species. It appears to be frequently an operation of considerable trouble and difficulty, and is preceded on each occasion by a short period of rest and abstinence. These moults are not equally distributed through the life of the caterpillar, and the longest interval is that between the last moult as a larva and that which produces the change to the pupa state.

The danger of attack by insectivorous birds and reptiles, by parasitic insects such as ichneumon flies belonging to the families *Ichneumonidæ* or *Braconidæ*, or dipterous flies belonging to the *Tachinidæ*, or by rapacious ones such as the fossorial Hymenoptera, many of which provision their nests with small caterpillars, are features in the life of those larvæ that feed in the open, which, together with the disturbing effect of storms, threatening to shake them from their perches, must give a little zest, if the creatures are only able to appreciate it, to an otherwise flat and tame existence. But in order to guard against such dangers, there is very little in the way of active resistance; indeed, the insects are so delicately constructed that it is not safe for them to struggle or fight; the soft-skinned body is kept in a tense condition by the fluid it contains, which is therefore under pressure, so that any little wound would occasion a considerable loss of blood, which would have the double effect of producing the enfeeblement that always follows blood-letting, and lessening the creature's control over its movements by making it flaccid. Hence a little damage to the skin might easily prove fatal, and therefore the caterpillar cannot afford to be very pugnacious, or to defend itself strenuously if attacked. Therefore the means used are mainly of the passive kind, such as are supplied by protective coloration, a clothing of hairs or spines, or the assumption of a particular attitude, and if these fail, the caterpillar has but to submit to its fate.

In the articles on ants, published in KNOWLEDGE some months ago, it was pointed out that some tropical species of ants assume a sort of guardianship over certain caterpillars for the sake of a secretion they yield, which is palatable to their guardians. A very curious instance of this has been recorded by a reliable American entomologist, the insect protected being the caterpillar of one of the "Blues," called *Lycæna pseudargiolus*. The larva was seen on its food-plant, and "on its back, facing towards the tail of the larva, stood motionless one of the larger ants. . . . At less than two inches behind the larva, on the stem, was a large ichneumon fly, watching its chance to thrust its ovipositor into the larva. I bent down the stem," says the observer, "and held it horizontally before me, without alarming either of the parties. The fly crawled a little nearer and rested, and again nearer, the ant making no sign. At length, after several advances, the fly turned its abdomen under and forward, thrust out its ovipositor, and strained itself to the utmost to reach its prey. The sting was just about to touch the extreme end of the larva, when the ant made a dash at the fly, which flew away, and, so long as I watched, did not return." The disturbance created by the ant's action apparently caused the caterpillar for the first time to realize its danger, and it immediately began to lash its fore parts from side to side, thus bringing into requisition its only means of defence.

Many caterpillars are internal feeders, and live within the trunks of trees, or the stems and roots of reeds, grasses, and other herbaceous plants, in the interior of fruits, or in mines between the cuticles of leaves. Here they are, of course, more out of the reach of their foes; lizards cannot get at them at all, while insectivorous birds find it much harder work to reach them, and there is small chance for the ichneumon flies, except for such as are provided with a long ovipositor to be thrust into the burrows. Hence the life of such caterpillars must be far more monotonous and uneventful than that of outside feeders. In particular, their locomotion is much restricted; they have to tunnel wherever they go, and sometimes, as in the case of leaf-miners, the whole area of their lifelong wanderings does not amount to more than a small fraction of a square inch. Such caterpillars do not possess the special means of protection by which their external-feeding relatives are distinguished; they are usually naked and whitish, and without adornment, and the walls of their prison-like home are a sufficient safeguard. It is curious that for the clearest indications of intelligence during larval life we must go to the smallest species; amongst the leaf-rollers, or Tortrices, some of which, such as the green oak moth (*Tortrix viridana*), completely strip the trees of their young leaves in early spring, and the Tineæ, the minutest of all Lepidoptera, we find some remarkable instances of constructive power, as shown in the making of shelters out of rolled-up leaves, or in the cutting out and piecing together of cases for the protection of the hinder part of the body. Some caterpillars, again, are social in habits, constructing a common abode in the form of a web.

A caterpillar has been called a "locomotive egg," in allusion to the primitive condition of its organization as compared with that of the adult insect. This primitive condition is shown partly in the entire absence of several structural details—such, for example, as wings, which the perfect insect is possessed of—and partly in the more rudimentary and less concentrated and specialized form of those that it possesses in common with the adult, when compared with what they will ultimately become; this characteristic is well shown in the condition of the nervous and reproductive systems. With regard to the former of these, there is in the adult a fusion of parts which are separate in the larva, the number of ganglia in the nervous chain being greatly reduced, while the nerve centres of the head and thorax are much increased in size. With regard to the latter, caterpillars are not sexually mature, and are therefore functionally neither male nor female; but the reproductive organs are actually present, though in a rudimentary condition, so that usually no difference is discernible externally between those that will produce male insects and those that will produce females. This is not, however, always the case; sometimes certain portions of the reproductive organs become sufficiently distinct to be able to be seen through the skin, and the separation of the sexes can thus be made; or again, there is a difference in ornamentation which is dependent upon sex—for example, the caterpillars of the vapourer moth (*Orgyia antiqua*), a common insect often seen even in the streets of large towns, are of very different sizes, the small ones producing males and the larger females, while they differ also in the colour of the tufts of hairs with which they are so fantastically adorned. From these details it will be seen that in caterpillars a condition of things is exhibited which would in some other animals be a merely transitory stage in their early embryonic history. On the other hand, the larval stage, which is not unfrequently the longest division of the insect's life, embraces the whole period of growth, and in fact the insect's actual bulk at the end of its caterpillar career is generally greater than during its subsequent history, the change into the chrysalis being attended with a diminution in size, while, in like manner, during that period, there is a gradual loss of weight, due

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largely to evaporation, so that the perfect insect is, as a rule, both smaller and lighter than the caterpillar which produced it. After caterpillar days are over there is no further growth in the sense of mere increase in bulk, but only in the sense of development, *i.e.*, gradual, though it looks like sudden, change of form of already existing organs, or the acquisition of new ones at the expense of matter already present in the organism.

Let us look now at the general structure of a caterpillar. Whatever be the peculiarities of its actual outline, its more or less cylindrical and worm-like frame is obviously divisible into two very unequal parts, head and body, the latter being again subdivided by constrictions at regular intervals into twelve segments. The head (Fig. 1) is covered with a hard skin, the greater part of the area of which is divided into two equal lobes (*a*), one on each side; from their position and their often highly-polished appearance they are rather suggestive of eyes, and are sometimes supposed to be such, an idea which is quite erroneous; the true eyes are twelve in number, six minute glassy knobs (Fig. 2) being placed on one side and six on the other, not far from the mouth apparatus. A lens is needed to see them properly, even in a large-sized caterpillar, and from their low position and their minute size they can hardly be of any great use to the insect; indeed, the groping movements of its fore parts, when it is not actually on its food-plant, seem to indicate a purblind condition, so that it probably conducts its movements as much by the sense of touch as by that of sight. That caterpillars are, however, sensitive to light to some extent has been shown in various ways. For example, the caterpillars of the small tortoiseshell butterfly (*Vanessa urticæ*), when kept in a glass cylinder before a window, have been found to take up their quarters on the side nearest the light, and when the cylinder was turned round so as to bring them over to the other side, they quickly shifted their position and assembled again in the sunlight. It is to be remembered that this species, when on its food-plant, the common stinging nettle, delights to cling round the topmost parts in the full glare of the sunshine, so that in confinement it was but endeavouring to follow out its own natural instincts. On the other hand, such species as feed in a more or less retired position would, no doubt, under similar circumstances, have sought the darkest corners of their prisons. Plateau has conducted experiments with the view of determining the extent of the visual powers of caterpillars and other insects. As a result of these experiments, he has been led to believe that the eyes of caterpillars are able to do more than merely distinguish light from darkness, and that the insects really do see, though but poorly. They are, in fact, very near-sighted, their distance of distinct vision being no more than about a centimetre, that is, under half an inch, quite far enough, however, to enable them to see to eat their food. At greater distances they can perceive large masses, but do not seem to be able to make out their nature. Moving bodies also do not affect them except within the range of distinct vision. Caterpillars seem to have a certain sense of direction; at any rate, they have a tendency to crawl *upward*, even when the route taken does not lead to their food-plant, a circumstance which appears to imply a recognition of the fact and direction of gravitation.

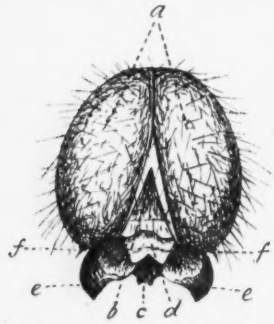

Fig. 1.—Head of Buff-Tip Caterpillar (*Pygæra bucephala*), with jaws open: *a*, lobes of face; *b*, clypeus; *c*, part of labium; *d*, labrum; *e*, mandibles; *f*, antennæ.

Fig. 2.—Cluster of ocelli of Silkworm Caterpillar; right side.

In the angle between the receding edges of the above-mentioned lobes is situated the *clypeus* (Fig. 1, *b*), a triangular area which forms the upper boundary of the feeding apparatus. On its lower edge abuts a movable lid, the *labrum* (*d*), or upper lip, which guards the entrance to the mouth above. Immediately below this is the most important part of the whole apparatus, a pair of exceedingly stout jaws, or *mandibles* (*e*), which are placed at the sides of the mouth, and when closed meet in front of its aperture. The lower border of the mouth is constituted by the *labium* (*c*), or lower lip, a complex structure formed by the coalescence of many parts. There is a central portion, which is the *labium* proper, with a pair of minute appendages, its *palpi*. The two side parts are the *maxillæ*, and these also carry palpi. On the central portion is the minute perforation which forms the opening of the ducts from the silk glands, whence issues, in the form of a thread, the gummy substance that is used for such a variety of purposes in different species, as for example, forming the cocoon or the attachment of the chrysalis to some support, binding leaves together to form a shelter, or creating a common dwelling-place in the form of a thick web, or serving as a means of anchorage and a ladder for return when a fall from the food-plant takes place. Finally, at the outermost edge of the mandibles are placed a pair of small jointed organs, similar to the palpi in structure, and capable of "telescoping up"; these are the antennæ (Fig. 1, *f*), which are much used in testing the path and surrounding objects. Close by the antennæ are situated the eyes, or rather ocelli. To verify these points it is well to secure as large a caterpillar as possible, since at the best of times none of the structures referred to are other than small. Insects such as the larva of the goat moth (*Cossus ligniperda*) which formed the subject of Lyonet's anatomizing a century ago, or the privet hawk moth (*Sphinx ligustri*) which served a similar purpose to Newport half a century later, answer very well; or in default of these, large specimens of that extremely abundant creature, the larva of the buff-tip (*Pygæra bucephala*), which in our own times furnished Sir John Lubbock with material for a careful study of caterpillar muscles, may be used.

(*To be continued.*)

THE REV. JOHN MICHELL, ASTRONOMER AND GEOLOGIST.

By John Richard Sutton, B.A.Cantab.

(*Continued from page* 191.)

AT forty-two years of age Michell settled down as Rector of Thornhill, Yorks, a small parish on the River Calder, between Huddersfield and Wakefield, memorable for its connection with the heroic royalism of the Saviles,* to whom the gift of the living belonged. Michell seems to have made the acquaintance of a member of this family at Cambridge, for a certain George Savile, of Queen's College (who was afterwards "Baronettus," and probably, therefore, the son and heir of Sir George Savile, of Thornhill), took the M.A. and LL.D degrees together in 1749†

* Whitaker's *Loidis and Elmete.* † *Cantabrigienses Graduati.*

(the year after Michell got his fellowship), chiefly, it would seem, in recognition of his wealth and prospects. It is a curious exemplification of the tenacity with which feudal instincts clung to the University in those comparatively recent days, that whereas "Philip, Duke of Newcastle, John, Earl of Sandwich, and George Savile, Esquire," *graced* all the public ceremonies of the University, the "Masters and Fellows in their robes" merely *attended*.

Mr. Ansted, who, by the way, knew more than most people about Michell, remarks that Michell "appears to have discontinued scientific pursuits on succeeding to the living; at all events," he adds, "nothing more was made public by him during the remainder of his life."* This is quite wrong, though, seventeen years afterwards, namely, in 1784, Michell published in the *Philosophical Transactions* an ably-reasoned article "on the means of discovering the distance, magnitude, &c., of the fixed stars, in consequence of the diminution in velocity of their light, in case such a diminution should be found to take place in any of them, &c." This discussion exhibits Michell's marvellous talents unimpaired; but it will not be necessary to consider it here, for it was founded on Newton's erroneous corpuscular theory of light, then generally accepted. Had that theory been tenable, Michell's subtle suggestions might have been applied with success in the course of time. As it was, when the corpuscles had succumbed to Young's vigorous assault, a modification of Michell's plans was adopted to find the velocities with which some of the stars are moving from or towards the earth, albeit nothing is learned in this way of their distances. One result worked out in this paper of 1784 is too pretty to be passed over. If, said he, light be sent out in the form of material particles from luminous bodies (as Newton supposed), these particles must be amenable to gravity, hence their original velocities would be considerably modified by the retarding action of the emitting bodies; and in cases where these last were large enough, the corpuscles would be forced to return to their starting places. The consequence would be that the larger stellar masses would be totally invisible. Advanced knowledge has taught us that this result is not in accordance with facts, and that the mass of the luminous body can have no effect on the velocity of the light it sends forth. Yet arriving, strangely enough, at some truth from erroneous premises, Michell managed to deduce the result, whose observational proof was not forthcoming for the best part of the following century, that by the motions of some of the bright stars we might be able to detect the existence of dark companions to them; and this, when astronomers as yet did not recognize the existence even of lucid binary systems.

In the seclusion of Thornhill, Michell thought out *and constructed* the celebrated torsion balance for weighing the earth. Doubtless it was the outcome of his magnetic experiments, not that he confounded magnetism with gravitation. It is still the best instrument we have for the purpose, and the measure of the earth's density obtained by this very instrument (somewhat modified, it is true, in minor details) gave the first measure of the earth's density. An explanation of the machine would be out of place here, but a complete account will be found in the *Philosophical Transactions* for 1789 by Michell's friend Henry Cavendish, who first used it, Michell having died too soon to use it himself.† There is also a simple account in Young's *General Astronomy*, and by the late Mr. Proctor in the early part of the *Old and New Astronomy*. Archimedes is reported to have said that, given a lever long enough, he would move the earth. Of Michell we may say that he showed how to put the earth in the balance and weigh it. In this, as in other things, Michell has been undervalued. He seldom gets the credit for his invention; more frequently than not it is stated that Cavendish himself designed the machine. Fortunately, Cavendish's own declaration to the Royal Society is explicit enough: "Many years ago," he says, "the late Rev. John Michell, of this Society, contrived a method of determining the density of the earth, by rendering sensible the attractions of small quantities of matter; but as he was engaged in other pursuits, he did not complete the apparatus till a short time before his death, and did not live to make any experiments with it. After his death the apparatus came to the Rev. Francis John Hyde Wollaston, Jacksonian Professor at Cambridge, who, not having convenience for making experiments with it in the manner he could wish, was so good as to give it to me." Nothing could possibly be clearer, and it may well seem surprising, in the face of such a statement, that misapprehension should afterwards arise. That it did arise is probably due to Lord Brougham, whose article on Cavendish was widely read.‡ Unfortunately, the well-merited drubbing he got from the *Quarterly Review*§ was not taken to heart by later writers as it should have been. Lord Brougham admitted subsequently that he had not so much as seen Cavendish's paper on the torsion balance before publishing his sentiments concerning it. But whereas many persons read the article wherein the invention of the torsion balance is assigned in large type to Cavendish, it is to be feared that few read the recantation in small type in an obscure corner of a later volume.

After a life of quiet usefulness, which will be more and more appreciated as time goes on, Michell passed away on the 21st of April, 1793. He was buried in the south chancel of St. Michael's, Thornhill. A flat plain stone marks the spot, and another by its side is in memory of his wife. The inscriptions are in plain capitals:—

(1) "REV. JOHN MICHELL,
DIED THE 21ST APRIL, 1793,
AGED 68 YEARS."

(2) "ANNE MICHELL,
RELICT OF THE REV. JOHN MICHELL,
DIED THE 3RD NOVEMBER, 1818,
AGED 86."

A nobly-worded but curiously punctuated tablet hangs in the church to Michell's memory, and to that of his brother. It runs thus:—

"In the chancel of this church are deposited the remains of the Revd. Jno. Michell, B.D., F.R.S., and 26 years Rector of this parish, Eminently distinguished as the Philosopher, the Scholar. He had a just claim to the character of the good Christian. In the relative and social duties of Life; the tender Husband, the indulgent Parent the affectionate Brother and the sincere Friend were the prominent features in a character uniformly amiable. His charities were not those of ostentation but of feeling. His strict discharge of his professional duties that of principle, not form. As he lived in the possession of the esteem of his parishioners, so he has carried to the grave their regret.

* *Cambridge Portfolio.*

† Michell and Cavendish were great friends, and made geological excursions together. Their acquaintance was, perhaps, first made at Cambridge. Cavendish entered at Peterhouse on November 24th, 1749, but left without taking a degree.

‡ See *Men of Letters and Science of the time of George III.*

§ *Quar. Rev.*, Vol. LXXVII., *passim.*

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"He died the 21st April, 1793, in the 69th year of his age.

"And in the same spot united in death as in life, the body of Gilbt. Michell, Esqr., Brother to the above, lies interred, a gentleman whose peculiar urbanity of manners and suavity of temper, attracted the love and esteem of all who knew him. In the conscientious discharge of all those offices which characterize the honest and good man. He was the counterpart of the above: united in the closest bonds of fraternal love. The union of virtuous and philanthropic sentiment was not less strict. For more than twenty years He was an ornament to and a valuable resiant [!] of this parish. He died the 15th Novr., 1792, aged 66.

"Gratitude and affection have erected this tablet to their memory." *

BYE-PRODUCTS *versus* WASTE-PRODUCTS.

By Vaughan Cornish, M.Sc., F.C.S.

THE well-known Leblanc process for making soda came into use about one hundred years ago. Till its introduction the alkali required in various manufactures was nearly all obtained from the ashes of plants. Potash, the alkali obtained from land plants, was more plentiful than soda, which is obtained from the ash of sea plants. The sodium of the soda yielded by sea plants is contained in the sea in the form of common salt. By Leblanc's process the soda is prepared directly from common salt, thus avoiding the tedious and uncertain collection of sea-weed. The first impetus which the new method received was in 1793, when France found herself deprived of alkali, which used to come chiefly from Russia and America. How serious was the inconvenience thus caused may be readily imagined, since the manufacture of soap and of glass is dependent on a supply of alkali.

Leblanc's process for preparing soda direct from salt relieved France from an industrial difficulty. It also changed the relative importance of the two alkalies, making soda much cheaper and more plentiful than potash. Leblanc himself died in a French workhouse, but manufacturers on this side of the Channel were more fortunate, and many of them accumulated wealth as rapidly as the iron-masters did in later times. The demand for soda was unlimited, and the sole object of the manufacturer was to produce as much of the article as possible. The materials for the manufacture are the following, viz.:—first, salt and sulphuric acid, which react on one another, producing "salt cake" (sulphate of soda) and hydrochloric acid gas; secondly, limestone and coal, which, being heated with the sulphate of soda, produce the required alkali, carbonate of soda, more commonly known simply as "soda." In this second reaction the final products, besides soda, are sulphide of calcium and carbonic acid gas. Leaving out of account this last substance, the product of all combustion, we see that in the manufacture of soda the waste products are, or were, two, viz.:—hydrochloric acid gas and sulphide of calcium, or "alkali-makers' waste." The former substance was allowed to escape into the atmosphere, killing all vegetation for miles around, whilst the latter accumulated in vast heaps in the neighbourhood of the works, constantly undergoing decomposition through the action of air and moisture, and poisoning the atmosphere with fumes of sulphuretted hydrogen, besides polluting the streams with the poisonous drainage of the decomposing mass. The alkali-maker cared for none of these things, and the Government found it necessary to legislate in order to protect the health and property of the manufacturer's neighbours. The manufacturers were compelled to condense and retain the fumes of hydrochloric acid, though the decomposition from the "waste" continued to be a nuisance to the neighbourhood. The alkali-maker being obliged to go to the expense of collecting the hydrochloric acid, set to work to compensate himself for the outlay involved, by utilizing the formerly waste product hydrochloric acid, which now became a bye-product of the manufacture. More recently a process has been introduced for recovering the valuable sulphur from the sulphide of calcium. Employing the same materials as formerly (salt, sulphuric acid, limestone, and coal), the principal products of the modern manufacture are three instead of one as formerly—that is to say soda, hydrochloric acid, and sulphur, instead of soda only. It is a singular fact that at the present time the Leblanc manufacturer produces the soda at a loss, while the bye-products yield a profitable return, sufficient to pay him the interest on the capital which is locked up in the huge plant of the alkali works. From the hydrochloric acid chlorine is now made, and the chlorine gas, passed over dry slacked lime, forms the bleaching powder which is used in enormous quantities for whitening cotton and other goods. Large quantities are also used for disinfecting purposes; the recent cholera scare, by the way, sent the price up in a manner most satisfactory to the makers. At first one of the chief items of expense in the manufacture of bleaching powder was the consumption of manganese dioxide, employed to set free chlorine gas from the hydrochloric acid. This is now "regenerated" by Weldon's process, in which the chloride of manganese formed in the reaction is acted upon by air and steam in the presence of lime, the final "waste" material being calcium chloride. Similarly, in Chance's process for the recovery of sulphur from the alkali-makers' waste, the same substance, calcium chloride, is the final waste product. Chance's process is conducted in two stages: first, the partial oxidation of the sulphide of calcium by air and steam, and secondly, the decomposition of the oxidized product by hydrochloric acid, in which sulphur separates out and calcium chloride is formed. Calcium chloride is a material for which there are but few applications, and it is practically "waste." The loss of calcium is not of importance, since abundance of the useful compounds of this element can always be obtained from natural sources, such as limestone. But the chlorine is valuable, and many efforts have been made to recover this element from calcium chloride. It is quite possible to set the gas free, but hitherto a sufficiently cheap and simple process has not been found, although much attention has been devoted to a problem the solution of which may yield a large fortune. Calcium chloride is indeed the final waste product in a large number of chemical processes.

We have mentioned that the soda made by the Leblanc manufacturers is now produced at a loss. This is due to the introduction of another method of manufacture, known as the ammonia-soda process, in which a purer product, commanding a higher price, is simply and quickly obtained. In this process carbonic acid gas is passed through water which contains, dissolved, both common salt and ammonia. Soda, in the form of the bicarbonate, is deposited from the solution in crystals, the carbonic acid uniting to the base

* The Rev. F. R. Grenside, M.A., Queen's College, Cambridge, the present Rector of Thornhill, has kindly furnished me with this copy of the memorial tablet. In sending it he remarks that it is impossible not to be struck with the fine style in which it is written. It is likely that the mason is responsible both for the punctuation and the spelling.

soda, and the ammonia taking the chlorine, forming ammonium chloride, which remains in solution. The conditions under which the soda is produced in this method of manufacture are very favourable to the formation of a pure product. Both by the solution of the common salt and by the subsequent crystallization of the carbonate of soda, impurities are eliminated. In the Leblanc process, on the other hand, impurities accumulate, and their subsequent removal involve time and expense. The second stage of the Leblanc process, as we have already stated, consists in the decomposition of sulphate of soda by means of limestone and coal. All these solid substances are heated together on the floor of a furnace. After cooling the mass is treated with water, which dissolves out the carbonate of soda and leaves behind the calcium sulphide and any unburnt coal. But the solution contains a good many other substances besides carbonate of soda, such as sodium sulphide and sodium thiocyanate, besides large quantities of caustic soda.

In spite of all disadvantages under which he suffers in competition with the ammonia-soda process, the once envied "Leblanc" manufacturer is still just able to maintain his business by the sale of the bye-products of the manufacture, made from what was formerly waste material. A full account of the various inventions by which the utilization of the bye-products has been brought about would fill a volume, and does in fact actually fill many volumes of technical literature. Chemistry as an industrial art is best studied in the districts where alkali is manufactured and is used for glass and soap making, in South Lancashire for instance, and in the districts such as the neighbourhood of Middlesbrough, where iron and steel are made. In both districts one may study the successive improvements by which the most is made of products formerly considered "waste." In the blast furnace, as was pointed out in the last number of KNOWLEDGE, the constant endeavour has been to utilize the energy of the half-burnt carbon so as to diminish the consumption of the raw material coal. In the Leblanc process the economy has been effected by the preparation of useful substances from useless materials. The iron-makers, like the alkali-makers, had hard times to meet, and they tided over the hardest time by reason of the improvements which care and foresight led them to introduce in the manufacture. The alkali-maker only turned his attention to economy of material when legislation compelled him to do so; but in his case, and in that of the more provident producer of iron (and, we might add, of manufacturers in all branches of industrial chemistry), prolonged prosperity has only been attained by minimizing wastefulness as much as the wasteful tendency of all natural change permits.

THE MOVEMENTS IN THE LINE OF SIGHT OF STARS AND NEBULÆ.

By MISS A. M. CLERKE, *Authoress of "The System of the Stars" and "The History of Astronomy during the Nineteenth Century," &c., &c.*

THE movements of the heavenly bodies directly towards or from the earth might well have seemed an element placed by the nature of things outside the scope of terrestrial enquiries. Yet it has proved capable of determination; not merely in a rough and general way, but in many cases with a precision answering to the strict demands of modern calculating astronomy. Hope has indeed been left a long way behind in this branch of research, and *Nil desperandum* might now, with full justification, be taken as their motto by adventurous astro-physicists. Through their achievements in measuring spectroscopic line-displacements in stars and nebulæ, sidereal science is becoming rapidly revolutionized: stellar systems, which might have been judged beforehand of improbable, not to say impossible construction, are found in full working order, and distributed with no extreme scarcity through space; promise is afforded of completely disentangling the translatory motion of the sun from the confused flittings of the stars; and materials are being provided for investigating their dynamical relations with greatly improved prospects of success.*

The theoretical possibility of spectroscopically measuring motion was recognized many years before it could be realized. First of all, Christian Doppler, in 1842, announced the fundamental principle that light-waves are altered in refrangibility, as sound-waves in pitch, by the recession or approach of the emitting bodies. But his use of the principle was utterly futile. The curious notion somehow laid hold of him that it would account for the varied colours of the stars; as if the invisible rays at either end of every ordinary stellar spectrum were not at hand to restore the chromatic balance, which might otherwise be infinitesimally disturbed by motion. Alone among his contemporaries, Fizeau perceived, in 1848, the real capabilities of the method; he saw that the shift of a spectrum might serve to determine radial velocity, and referred to the Fraunhofer lines as the natural indices to the amount of the shift.

Nobody, however, at that time knew anything about the origin of the Fraunhofer lines, nor was it by any means certain that they possessed the essential fixity needed to make their incidental displacements of critical value. Fizeau's suggestion had sunk into oblivion when, after twenty years, Dr. Huggins practically demonstrated its importance. His success was decisive. The effectiveness in sidereal investigations of the spectroscopic method of determining radial motion was thenceforward generally admitted, and its application became one of the recognized tasks of astronomers.

But the requisite visual observations are hampered by very great difficulties. Starlight does not readily endure high dispersion. Unless when concentrated by telescopes of immense apertures it ceases, as it were, to be *articulate* if enfeebled through extension. Its characteristic rays—the very objects of measurement—fade into evanescence. Without high dispersion, on the other hand, their minute displacements are apt to get disguised or exaggerated by atmospheric tremors. Both these inconveniences can fortunately be obviated by substituting photographic for direct

[* Miss Clerke takes a much more hopeful view of the accuracy of recent determinations of motion in the line of sight than I feel that I am able to take. Up to the present time there have been very serious differences in the estimates made by the best observers as to the amount and even as to the direction of motion, towards or away from us, of stars and nebulæ. Dr. Vogel has no doubt succeeded in eliminating some sources of error due to flexure of the spectroscope and other causes, and it will be welcome news to all interested if his estimates of the amount of his errors are confirmed by the observations of other spectroscopic observers. But at present the results independently obtained in this line of research differ more from one another than the determinations of parallax differ. It therefore seems to me unsafe to build on such foundations when forming conclusions as to the stellar universe. My remarks do not apply to measures of the relative motions of adjacent stars in the line of sight, such as led to the discovery by Prof. Pickering of binary stars too close to be visibly separated in the largest telescopes. In spite of what I have said, I feel that Miss Clerke's statement of the case for Dr. Vogel is very interesting.—A. C. RANYARD.]

[What Mr. Ranyard says in his note is undoubtedly true as regards a good many of the Potsdam stars; but the only two which have been independently measured with adequate means have given identical results with those obtained by Dr. Vogel. These are, as mentioned in the article, Arcturus and Aldebaran.—A. M. CLERKE.]

observation. The extreme sensitiveness of modern plates causes a little light to go a long way in producing legible impressions; and these impressions firmly hold their ground against aerial vibrations as regards position, suffering only some slight prejudice in point of definition.

Since 1887, accordingly, Dr. Vogel, aided very effectually by Dr. Scheiner, has been engaged in perfecting the "spectrographic" method, and with so prosperous an issue as to ensure its wide adoption. The accuracy attained, in fact, is, under favourable circumstances, of so high an order as to give hope of an eventual reactive effect in correcting the values at present assigned to the dimensions of the solar system; for the orbital travelling of the earth, now in a positive, now in a negative direction, necessarily records itself, in varying but determinable proportions, on each plate exposed to the prismatic rays of the stars. The measured displacements have then to be cleared of its effects, their residue giving the constant quantity of stellar movement towards or from the sun. The terrestrial speed is of necessity, at the actual stage of the enquiry, taken as known, the star's movement being treated as unknown. But with some further advance in exactitude, this relation may in the future be inverted, and the earth's rate of circulation determined anew by subtracting from the gross amounts of measured velocity the known movement of some star. Thus the great astronomical unit of the sun's distance will perhaps before long come to be more satisfactorily ascertained, through seemingly insignificant modifications of stellar spectra, than it has yet been by means of transits of Venus, oppositions of Mars, or laborious experiments on the swift travelling of light.

Spectroscopic determinations of motion might almost be said to be unconditioned by either time or space. They are independent of distance, provided only the concentrated rays they deal with retain sufficient intensity for the purposes of analysis; and they give results absolutely, and at once. "Proper," or thwartwise motions have to be gathered in slowly, decade by decade, even century by century; but end-on motions put no strain of waiting on human impatience. Five years have hence sufficed for the execution of the immediate part of the task undertaken at Potsdam. Those five years, moreover, were mainly spent in the development of untried methods, in the invention and construction of novel apparatus. The work was of the pioneering sort, and could not proceed with the same rapidity as if the path of its progress had been long ago smoothed and straightened. Its results, now published in detail,* claim a peculiar and unique interest. They are the first of their kind, and they imply the promise of much more than they actually give. Their substantive importance, nevertheless, is great. The fifty-one stars measured are all those suitably situated, and bright enough for the grasp of a 12-inch refractor. With a larger instrument, in course of construction, Dr. Vogel hopes to deal similarly with a longer list of fainter stars, and thus to collect sufficient materials for solving the problem of the sun's motion in space—above all, one may add, for fixing the rate of that motion, so far entirely unknown.

The first notable point about the motions in line of sight just now published is their moderate speed. The average velocity of the collection comes out no more than 10·4 English miles per second. And this, it must be remembered, includes the effect of the solar translation, which may accordingly be surmised to progress at a slower pace than had of late been more or less conjecturally assigned to it. The highest velocity determined at Potsdam belongs to Aldebaran, which recedes from us by thirty miles a second, γ Leonis coming next with twenty-four miles of approach. There is a total absence of startling records; nicety of observation has been strongly operative in slackening pace. Dr. Vogel's stars travel at moderate, decorous, and explicable rates. No such celestial projectiles occur among them as μ Cassiopeiæ or Groombridge 1830, no correlatives even of ζ Toucanæ or 40 Eridani. Moreover, the average rate of advance along great circles of the sphere of fifty-one stars with ascertained proper motions, and at more or less reliably known distances, appears to be about thirty-four miles a second, or more than thrice the average radial speed of an equal number of—it may be well to remark—much brighter stars. The disparity is striking, but it may possibly be reconciled by further research.

The "goal of the sun's way" may now be placed, with some confidence, in the neighbourhood of the brilliant Vega—let us say, taking the mean of M. Oscar Stumpe's recent determinations, in R. A. 285°, Dec. +38°. In that quarter of the heavens, then, movements of approach must considerably outweigh movements of recession, while, in the opposite quarter near the sun's "anti-apex," the relation is doubtless inverted. But here the stars are, for the most part, invisible in northern latitudes, so that negative motion —motion, that is to say, serving to curtail distance— ought, on the whole, to predominate in the Potsdam list. Of the stars included in it, accordingly, thirty-one are approaching, only twenty receding from our system; while the proportion of stars possessing a negative to those showing a positive velocity above the average of 10·4 miles a second in either sense, is eleven to seven. The inequality would, however, presumably be removed if the observed stars were fairly divided between the northern and the southern hemispheres.

The adopted velocities in the Potsdam table are the means of independent measures by Drs. Vogel and Scheiner. These, in most cases, agree well; in some, they are nearly identical. Yet discordances are not wholly absent. Little reliance, for instance, can be placed on the ostensible result for γ Cassiopeiæ, which, according to Vogel, recedes from the earth at the rate of 2·5 miles, yet was found by Scheiner to have an approaching speed of 6·9 miles a second. Both observers, on the other hand, agreed as to the negative direction of the movement of Sirius; but the velocity assigned by Vogel was of 8·4, by Scheiner of 12·5 miles a second. This discrepancy is indeed minute compared with those which affected the earlier visual estimates of this star's motion. They wore, too, a delusive aspect of periodicity difficult to be accounted for by the mere vagaries of instrumental error. First, the recession attributed to the star gradually diminished its rate between 1868 and 1882, from twenty-five to two miles per second; then the direction of motion seemed to become reversed, and approaching velocities, increasing with the same semblance of regularity, were registered. The change, although ten times greater than could be accounted for by the known revolutions of Sirius round its dim companion, appeared to proceed with such steadiness and consistency that few questioned its genuineness. Yet, it is now fully admitted to have been altogether illusory. The Sirian system, there can be little doubt, is transported towards the solar system at about the same rate of ten miles a second with which it moves across our visual line. But the sun is travelling away from the star, which is situated in the immediate vicinity of the solar anti-apex. Its radial motion hence represents a gain upon the sun. Besides the measurable ten miles a second, Sirius possesses,

* "Publicationen des Astrophysikalischen Observatoriums zu Potsdam." Von H. C. Vogel. Band VII., Theil I. Potsdam, 1892.

then, nearly the whole of the solar speed, and the sum has to be further increased by being compounded with a visible or tangential movement of ten miles a second; so that the Dog-star traverses space probably about twice as quickly as the sun.

Arcturus furnishes another notable instance of the surrender, on closer enquiry, of a fictitious velocity. Its original seeming approach of fifty-five miles has dwindled, at Potsdam, to 4·6 miles a second—a result in all but perfect agreement with that independently obtained by Professor Keeler with the great Lick refractor. His measures were made upon the D-lines in the spectrum of the star; and a similar determination of Aldebaran by Mr. W. W. Campbell shows recession to the amount of 30·5 miles, the Potsdam photographs giving 30·2 miles per second. The former inferiority of the visual to the chemical method of ascertaining the radial movements of stars thus seems at last abolished; though not always or everywhere. The Lick atmosphere and the Lick telescope form a hitherto unmatched combination, and the signal advantages conferred by them have been illustrated by an important discovery. Owing to the enormous supply of light at his command, Professor Keeler was able to execute micrometrical measures in nebular spectra of the fourth order, the dispersion, equal to that given by twenty-four prisms of 60°, being effected by a Rowland's grating of 14,438 lines to the inch. The upshot was the detection of motion-displacements of considerable magnitudes. Until then nebulæ had appeared absolutely stationary; they yielded no certain sign, telescopic or spectroscopic, of mobility in any direction. The removal of this seeming anomaly constituted an advance of no small moment. The outcome of Professor Keeler's experiments was more decisive than could have been anticipated. The mean velocity towards or from the earth of the eleven nebulæ measured (including that in Orion), proved to be once and a half times that of the Potsdam stars, or sixteen miles a second.* Eight of these showed movements of approach, only three movements of recession. The disparity, however, was doubtless due to their situation mainly in the hemisphere *in front* of the sun. The most rapid traveller amongst them is the celebrated planetary in Draco (N.G.C. 6543 = H. IV., 37), found by Professors Holden and Schaeberle to possess a curious helical structure. Prolonged observations have as yet elicited from it no trace of proper motion; yet its rate of transport in our direction turns out to exceed forty miles a second. The swiftest motion of recession—twenty-eight miles a second—belongs to a small stellar nebula (N.G.C. 6790); the well-known "Saturn planetary" in Aquarius advancing at a nearly equal rate. So far as these preliminary trials go, then, nebular take the lead of stellar movements in the line of sight.

The Orion nebula recedes from the sun, or we should perhaps rather say the sun leaves it behind at the rate of 10·6 miles a second. A solar velocity of 13·6 miles, directed towards a point some ten degrees east of α Lyræ, would completely account for the observed line-displacements in the spectrum of that amazing object, and allow us to adopt the plausible hypothesis that the vast system of which it forms the nucleus exists in a state of comparative rest. It may be worth notice that the three stars, α, β, and ζ Orionis, share the virtual retreat from the earth of the chaotic mass adjacent to them on the sphere, and perhaps not disconnected from them in space. Another example of related motion in the stellar members of a nebulous system is most likely met with in α and γ Cygni. Both stars are pretty clearly shown in M. Wolf's photographs—as the readers of KNOWLEDGE for October, 1891, may remember—to be involved in the outskirts of the same extensive nebula; and they are found to be endowed with what may be fairly called a combined movement towards the sun of four or five miles a second. If this were purely a transferred effect of the solar translation, it would imply for it a speed of only 5·3 miles a second, which seems unreasonably small. The alternative supposition is perhaps to be preferred—namely, that the sun tends to overtake the star-and-nebula system, which travels in the same direction, but at a slower pace. Such points, however, can scarcely yet be profitably debated; they can certainly not be decided until a complete solution of the problem of the solar movement is at hand, based on materials derived in equal measure from the southern and northern hemispheres. The nature of the required data could not be better exemplified than by the specimen-lists of radial velocities provided from Potsdam and Lick.

* Reducing to the true wave-length of the chief nebular line, as subsequently fixed by Keeler himself at 5005·95 of Angström's scale.

Notices of Books.

La Planète Mars et ses conditions d'habitabilité. Par Camille Flammarion. (Gauthier-Villars, Paris.)—M. Flammarion has presented the world with a very important monograph on the planet Mars, to which he has devoted much time and labour. The volume, which is a large octavo and extends to 600 pages, contains over 300 beautiful woodcuts, in which M. Flammarion has reproduced 580 drawings of the planet by the principal observers of Mars. Nothing of any importance seems to have escaped him. Beginning with Fontana's very rough sketches made in 1636, and ending with drawings made during the present opposition, in addition to sketches and drawings made by other observers, he has also given many beautiful drawings of his own, and admirable maps of the chief planetary features. M. Flammarion is of opinion that Mars is or may be inhabited, and that a very large number of the canals and other details delineated have a real existence, and are not due to any optical illusion. But some of the drawings, especially those of the Schiaparelli type, which he gives are very diagrammatic, and so unlike the projection of markings on a sphere that they forcibly suggest that the canals and straight dark lines must be the result of some optical illusion.

Jupiter and his System. By Ellen M. Clerke. (Edward Stanford, Cockspur Street, London.)—Miss E. M. Clerke has taken the opportunity of the present very favourable opposition of Jupiter to give the public a lucidly-written account of what is known about the physical condition of the giant planet. Miss Clerke, like her better known sister the authoress of "The System of the Stars," writes very plainly and interestingly, and her little book is likely to turn the eyes and the thoughts of a great many fresh observers to the changes continually going on upon this magnificent planet. Many of these changes and other phenomena observable on the planet may be easily seen with small instrumental means, especially when Jupiter is in opposition. Like Mars, Jupiter is most favourably situated for observation when it is in the opposite quarter of the heavens from the sun. It crosses the meridian at midnight, and the illuminated disc is turned full upon us. The earth is then between the sun and Jupiter, and when Jupiter is near to perihelion, as at the present opposition, the earth's distance from the planet is only 369 million miles, whereas when Jupiter

is in aphelion the earth's distance from the planet is 411 million miles. Consequently, at an October opposition, when Jupiter is in perihelion, he appears nearly 40 per cent. brighter than at an April opposition when he is in aphelion. Jupiter presents a great many analogies with the sun. Its density compared with water is 1·378, whereas the density of the sun is slightly greater, viz., 1·444. As in the case of the sun's photosphere, the equatorial regions of Jupiter revolve a little more rapidly than the regions more to the north and south, thus proving Jupiter to be, like the sun, mainly a gaseous body. Its surface, however, presents a very different appearance from the sun's surface. The disc of the planet is crossed by dark belts of cloud which are continually changing their form. On the belts and between them are seen black, white, and reddish spots. Miss Clerke gives an interesting account of one of the largest and most permanent of these, known as the "Great Red Spot." It was first observed by Prof. Pritchett, of Glasgow, Missouri, in 1868, and soon attracted considerable attention. After three years of conspicuous brightness its colour began to fade, till in 1882-83 it had almost ceased to be visible. In 1885 it had begun to recover in brightness and then showed as a faint pink oval ring, with its centre occupied by a white cloud, which in the following year so extended as almost to obliterate its outline. The veil has, however, since cleared away, and left it as an elongated brick-red spot which moves somewhat slower than other markings in the same latitude. The different velocities gave occasion for an interesting observation by Mr. Stanley Williams on the conjunction of the red spot with a dark one, which is a fairly persistent feature of the planet. Its size was such that it would cover about half the shorter diameter of the greater spot if it should pass above it, and its relative speed was sufficient to carry it across its length in two months. The question how it would behave under these circumstances was one of considerable interest, for, its transit above or below the red spot would show which of these classes of objects occupied the higher level in the planet's atmosphere. Miss Clerke remarks that the black spot contrived to baffle expectant astronomers by doing neither. It took a third course and went round the obstacle, swerving away to the south and coasting the southern rim of the red spot. We can heartily recommend Miss Clerke's little shilling monograph, and hope that it will start many a reader in the pleasant paths of observational astronomy.

Mr. Barnard has kindly sent for reproduction in KNOWLEDGE some beautiful photographs of Swift's comet, showing remarkable structure in the coma and tail, and proving that the structure changed very rapidly from day to day.

One of the results of Mr. Burnham's departure from the Lick Observatory is that a Chicago millionaire, Mr. Charles T. Yerkes, has undertaken to present the University of Chicago with a refractor of 45 inches in diameter—that is, the object-glass will have a diameter greater by 9 inches than that of the great Lick telescope. He has commissioned Mr. Burnham and Prof. Geo. E. Hale to order the instrument, the object-glass of which will be made by Messrs. Alvan Clark. It has been truly said that with these large instruments the man at the small end of the telescope is the most important part of the equipment. With such a telescope, and such an observer as Mr. Burnham to use it, Chicago ought to make its mark in the history of astronomy.

Letter.

[The Editor does not hold himself responsible for the opinions or statements of correspondents.]

To the Editor of KNOWLEDGE.

SIR,—In the interesting article in the last number of KNOWLEDGE on "What is a Nebula?" Mr. Ranyard draws a vivid conception of the extreme tenuity of nebular matter. It seems to involve, however, a question which, to my uninformed mind, is very mysterious. I assume the following statements to be substantially correct:—

1st. The spectrum of such nebular matter shows it to be, in a great number of cases, gaseous.

2nd. Its luminosity means also high temperature.

3rd. The temperature of ethereal space is immensely lower than anything we have experience of.

Under such conditions, how is it possible that this nebular matter can maintain its luminosity and its temperature for a period indefinitely long? If it is true that all substances cool down by radiation into colder space, one would think that a nebula ought to disappear almost as soon as it is formed, instead of streaming out its light for ages.

Middlesbro', Oct. 22nd, 1892. R. H.

[We are hardly in a position to say that luminosity necessarily indicates a high temperature. The light of the glow-worm is evidently produced at a low temperature—and the auroral light is given out by matter in the cold regions of our upper atmosphere. It may be that the nebular matter is not all glowing, but that only the matter in isolated and widely separated regions is caused to glow by electrical discharges, or the impact of meteors. Personally, I do not incline to the latter theory, or to the theory of illumination by electrical discharges, but I will explain my ideas in a further paper on nebulæ, for which there is not room in the present number.

I have to thank Mr. Walter Sang for pointing out a numerical mistake in my last article on nebulæ. The density of atmospheric air at the sea-level at standard temperature and pressure is $\frac{1}{769\cdot5}$ of the density of water, not $\frac{1}{816}$. And the velocity of our sun in a circular orbit about the Orion nebula at the distance of α Centauri, assuming the conditions as to density and volume of the nebula mentioned in the last number, would be 7·5 miles, not 18 miles a second. If the nebula had a millionth of the density of atmospheric air, the velocity of our sun in a circular orbit about the nebula, if it were situated at the distance of α Centauri from us, would be 75·08 miles a second, and whatever the distance of the nebula under the conditions assumed, the angular velocity of our sun in a circular orbit, as seen from the nebula, would be constant. Similarly, the angular velocity in any elliptic or parabolic orbit would be constant, and the apparent velocities of stars moving under the control of gravity in the neighbourhood of the nebula, as seen from the earth, would be independent of the distance of the nebula.—A. C. RANYARD.]

THE OLDEST MAMMALS.

By R. LYDEKKER, B.A.Cantab.

UP to the year 1818 it was a generally received axiom of geology that mammals were totally unknown before the tertiary period; and that period was consequently designated the age of mammals—a name, by the way, which is still perfectly appropriate, if taken to imply that these animals then, and then only, became the dominant inhabitants of the world. In that year, however, the illustrious Cuvier,

during a visit to the museum at Oxford, was shown two minute jaws, carrying a number of cusped teeth, which had been obtained in the neighbouring quarries of Stonesfield, from the rock known as the Stonesfield slate, belonging to the lower part of the great jurassic, or oolitic, system. After careful examination, the French anatomist pronounced confidently that these two tiny little jaws, neither of which exceeded an inch in length, were those of mammals, and he further suggested that they would prove to belong to a species of opossum. Although this opinion was given in the year 1818, it does not appear that it was published till the year 1825, when the second edition of the fifth volume of the immortal "Ossements Fosiles" saw the light. In publishing this epoch-making notice of the occurrence of mammals in the secondary period, Cuvier, with the usual caution of naturalists, was careful to add the proviso that everything depended on whether the specimens he saw had really been obtained from the Stonesfield slate. Unfortunately, there does not appear to be any record stating by whom, or at what date, these original specimens—now forming some of the most valued treasures of the Oxford Museum—were obtained from the Stonesfield slate; but that they did come from that formation is perfectly certain. Indeed, other specimens have been subsequently obtained from the same beds, showing certain characteristic Stonesfield shells embedded in the fragments of rock in which the mammalian jaws are contained. Here we may mention that the Stonesfield slate is the equivalent of the lower portion of the great, or Bath, oolite—a deposit which is separated from the underlying lias by the beds known as the inferior oolite. Consequently, the mammal-yielding beds are separated from the rocks of the tertiary period, not only by the immense series of cretaceous deposits (chalk, gault, greensands, and wealden), but likewise by a large thickness of those belonging to the jurassic system, such as the Purbeck and Portland oolites, the Kimeridge clay, the coral rag, and the Oxford clay.

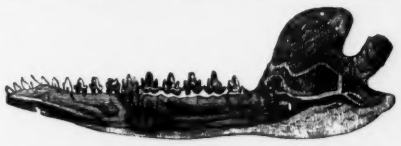

FIG. 1.—One half of the lower jaw of a Stonesfield Mammal; twice natural size. The restoration of the front teeth is conjectural.

Needless to say, no sooner was the existence of mammals in the Stonesfield slate announced than it was received with a howl of incredulity. First of all it was attempted to show that the specimens themselves did not come from Stonesfield; and no sooner was this objection knocked on the head than doubts were raised as to the jurassic age of the Stonesfield slate itself. These, however, were equally soon disposed of, and the only thing then remaining was to dispute the mammalian nature of the fossils. This task was undertaken by the French naturalist, De Blainville, who attempted to show that the mammalian character of the specimens was not proved by the double roots of their molar teeth. In the course of the argument, great stress was laid on the circumstance that two-rooted molars were found in a gigantic animal from the eocene of the United States, then known as *Basilosaurus*, and regarded as a reptile. De Blainville was, however, here treading on very dangerous ground, for it subsequently turned out that *Basilosaurus* itself was really a mammal, which is now generally placed among the whales, under the name of *Zeuglodon*. The correctness of Cuvier's original determination was thus in the end triumphantly sustained, and the existence of jurassic mammals became henceforth an established fact in geology, although the suggestion that these fossils belonged to opossums was, of course, unfounded.

Passing on to the consideration of the specimens themselves, we find that the great peculiarity of the jaws of these Stonesfield mammals (for one of which De Blainville proposed the name of amphithere) is the excessive number of their cheek-teeth, a feature now paralleled (as we have mentioned in an earlier article on "Pouched Mammals") only in the little banded ant-eater of Australia. This multiplicity of teeth is well shown in the jaw represented in Fig. 1, which is preserved in the museum at York, and shows upwards of nine cheek-teeth still remaining, whereas in practically all existing mammals with complex teeth, except the banded ant-eater, the number does not exceed seven. Other jaws were, however, subsequently discovered in Stonesfield, in which the number of cheek-teeth was considerably less; but one of these later specimens (described as the phascolothere), revealed the important fact that there were four pairs of front or incisor teeth in the lower jaw. Now since (as stated in the article cited) it is only among pouched mammals, or marsupials, that more than three pairs of incisor teeth are found, while the banded ant-eater, with its numerous cheek-teeth, is a member of the same group, it became a very natural conclusion that the Stonesfield mammals were likewise marsupials. Support was lent to this conclusion by the circumstance that, with the exception of the egg-laying mammals, or monotremes (to which a special article in KNOWLEDGE has likewise been devoted), the marsupials are the lowest of all living mammals. And indirectly some further support to this view is afforded by the fact that Australia still retains other forms of animal life allied to those which were living in Europe during the period of the Stonesfield slate. For instance, it is in the Australian seas alone that there still survives the solitary representative of the beautiful genus of bivalve shells known as *Trigonia*, which were so especially abundant in the oolites; while it is also there alone that swims the Port Jackson shark, whose mouth is armed with a pavement of crushing teeth, recalling those of many of its jurassic forerunners. Moreover, in the presence of numerous cicads among its flora, Australia again recalls the jurassic epoch of Europe; and it has accordingly been suggested that modern Australia might be regarded as a kind of direct survival from jurassic times. Before, however, we can say anything more as to the affinities of the Stonesfield mammals, we must turn our attention to subsequent discoveries of mammalian remains in other formations.

The first of these discoveries was made in the year 1847, by Professor Plieninger, of Stuttgart, who obtained certain minute teeth from a bone-bed near that town belonging to the upper part of the triassic period, which were declared to be mammalian, and for the owner of which the name *Microlestes* was proposed. Now, as the trias lies below the lias, the existence of mammalian life was by this discovery

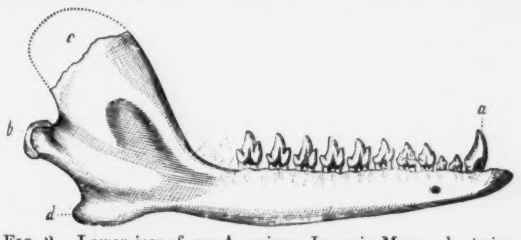

FIG. 2.—Lower jaw of an American Jurassic Mammal; twice natural size. (After Marsh.)

carried back at one bound very nearly to the commencement of the secondary period. Subsequently, mammalian remains were obtained from the trias of Somerset, which proved to belong to the same genus as those from Stuttgart, while others of a different type were found in the equivalent deposits of North America.

A little later, the year 1854 was made memorable by the first discovery of mammalian remains in the freshwater Purbeck strata of Dorsetshire, belonging to the very top of the jurassic system; from which formation in subsequent years a vast number of such remains were obtained, through the energy of the Rev. P. B. Brodie and the late Mr. Beccles. All these specimens were obtained from a single bed, and many of them indicated forms more or less closely allied to those from Stonesfield and Stuttgart. It was thus shown, once for all, that mammalian life must have been locally abundant throughout the jurassic period. This conclusion was subsequently amplified by the discovery in the upper jurassic rocks of North America

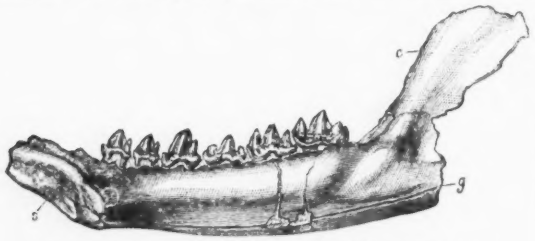

Fig. 3.—Lower jaw of *Triconodon*; half natural size. (After Marsh.)

of a whole host of small mammals very closely allied to those from Dorsetshire, a large number of which have been described by Prof. O. C. Marsh, some of whose figures are here reproduced. Many of these small jurassic mammals (Figs. 2 and 3) were evidently carnivorous, and such carnivorous forms exhibited two distinct types of dentition. In one of them (Fig. 2) there was a numerous series of cheek-teeth behind the tusk, or canine (*a*), each of which carried three cusps arranged in a triangle; while in the other type (Fig. 3) the cheek-teeth were fewer in number, and had the three cusps on their crowns ranged in the same line. From this peculiarity the animal to which the second type of jaw belonged was appropriately named *Triconodon*. The first type corresponds to the amphithere of the Stonesfield slate, while the second is more like the phascolothere of the same formation.

In our third figure it will be observed that there is a peculiar groove (*g*) running along the inside of the jaw, and since a similar groove is found among existing mammals only in the banded ant-eater and certain other carnivorous marsupials, we have pretty conclusive evidence that *Triconodon* and its allies were really marsupials. There can also be but little doubt that the species of the amphitherian type (I avoid mentioning the numerous genera of these animals) are likewise members of the same order. It is, however, quite possible that some of the jurassic mammals of Dorsetshire and North America may be more nearly allied to that primitive group of mammals known as Insectivores, among which are included the mole, the shrew, and the hedgehog of Europe, as well as the more generalized tenrec of Madagascar, and many other peculiar creatures. All these insectivores are of a very low grade of organization, and the result of modern researches is to show that their connection with the marsupials is very close indeed. Hence it is highly likely that some of the jurassic mammals may have been the actual connecting links between the marsupials and the insectivores; and it is worthy of mention here that while marsupials at the present day linger on only in Australia and America, some of the most primitive types of insectivores are preserved to us in Madagascar, which is another refuge for animals of a low grade of organization.

There is yet another type of mammal found in the English and American jurassics, to which the *Microlestes* of the trias also appears to belong, which has given rise to a vast amount of discussion among palæontologists. These remarkable mammals

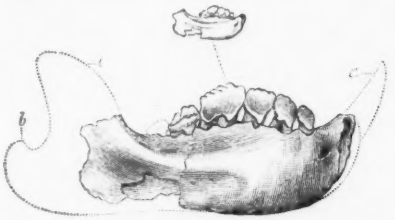

Fig. 4.—Lower jaw of *Plagiaulax*; natural size and enlarged. (After Marsh.)

are mostly of very minute size, and were long known only by their lower jaws, of which a specimen is represented in the accompanying figure; from which it will be seen at a glance that the dentition is quite different from that of either of the carnivorous types figured above. The lower teeth comprise a single large incisor (*c*), behind which were either three or four tall premolar teeth with cutting edges, and marked on the sides with a number of oblique grooves, from which the name *Plagiaulax* was taken. When unworn, these grooves extended along the whole outer surface of the teeth, but when the teeth have been long in use (as in our figure) the groovings become worn away from the sides. Behind these four premolars are two smaller molar teeth, with the summits of their crowns marked by a single longitudinal groove bounded by prominent ridges. Now it was argued at first that this very peculiar type of dentition indicated carnivorous habits in the owners thereof; but it was subsequently pointed out that the existing rat-kangaroos of Australia (of which the front of the skull is shown in Fig. 5) presented a somewhat similar type of tooth-structure. Thus, the last premolar tooth (*pm.*) of the rat-kangaroo has a cutting-crown marked with a number of parallel grooves; while each half of the lower jaw terminates in a single large incisor not unlike that of the jurassic *Plagiaulax*. Hence it was argued—and, in our opinion, argued rightly—that as the living form is herbivorous, the same must have been the case with the extinct one. When, however, it was also urged that the rat-kangaroo and *Plagiaulax* were closely allied animals, important differences between the two were overlooked. Thus, as will be apparent from the figures, while in the former there was but one grooved tooth, in which the grooves are *vertical*, in the latter there were usually three or four such teeth in which the grooves are *oblique*. Moreover, whereas the recent form was provided with four molar teeth (*m* 1—*m* 4), the fossil had but two such teeth; while the form of these teeth was quite unlike in the two. Hence, when we add that there are other important differences between them

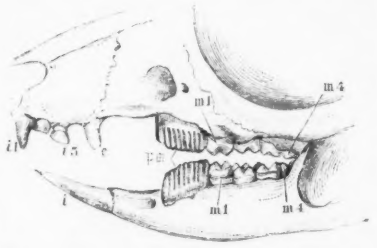

Fig. 5.—Jaws and teeth of the Rat-Kangaroo.

(into the consideration of which it would be difficult to enter here), it will be apparent that the view of regarding *Plagiaulax* as a new ally of the rat-kangaroo was the result of attaching too much importance to resemblances, and overlooking differences. Indeed, such resemblances as do exist between the two may be regarded merely as a well-marked instance of the phenomenon known as *parallelism*, which has only lately received at the hands of zoologists the amount of attention it merits. By parallelism, we may explain, is meant a more or less marked resemblance between homologous organs or parts, which has been acquired independently, and is not the result of direct inheritance. An excellent instance of parallelism is afforded by the development of cannon-bones in the horse and the ox, such cannon-bone consisting in the one case of a single metacarpal element, and in the other of two such metacarpals fitted together. Taking it, then, as proved that *Plagiaulax* is not a near ally of the rat-kangaroo, we have to consider whether it can be affiliated to any other group of existing mammals. Before doing so, we have, however, to mention that there are certain other secondary mammals allied to *Plagiaulax*, in which the whole of the cheek-teeth are like the true molars of the latter. We have already stated that in *Plagiaulax* the lower molars had a median longitudinal groove, and it may be added that the ridges bordering such grooves are surmounted by a number of small tubercles. In the upper jaw, if we may judge by some allied genera, the molars had three such tuberculated ridges, separated by two grooves. Similar molars occur in the skull represented in Fig. 6, which is that of a mammal discovered a few years ago in the secondary rocks of South Africa, and named by Sir R. Owen *Tritylodon*; but it will be noticed that there is no trace of the cutting and obliquely-grooved premolar teeth of *Plagiaulax*, the premolars being like the molars. Detached molars of similar type have been found (as mentioned in our article on "Egg-laying Mammals") in the trias of Stuttgart, and others occur in the Stonesfield slate. Moreover, in Dorsetshire and North America there are certain nearly allied mammals (*Bolodon*) in which the upper molars have only two, in place of three, longitudinal ridges of tubercles. These forms, if other proofs were wanting, clearly show, indeed, that the resemblance between *Plagiaulax* and the rat-kangaroo is not a genetic one. When, however, the molar teeth of the type in which there are but two longitudinal rows of tubercles are compared with the transitory teeth of the Australian duckbill (see article on "Egg-laying Mammals"), a certain resemblance can be detected between the two, which seems sufficient to indicate (as mentioned in that article) that in *Plagiaulax* and *Tritylodon* we have to do in all probability with ancient types of egg-laying mammals.

Fig. 6.—Under part of the skull of a South African Secondary Mammal; two-thirds natural size.

Till within the last few years the cretaceous period formed a complete gap as regards the history of mammals; and seeing that in Europe, with the exception of the wealden, the rocks of this system are mainly of marine origin, while some of them, like the chalk, were laid down in seas of considerable depth, this absence of mammalian remains is not to be wondered at. In the United States the condition of things is, however, very different. There the uppermost cretaceous rocks are of fresh-water origin, and constitute a series known as the Laramie, which is in intimate connection with the lower part of the tertiary, and has yielded the extraordinary horned dinosaurs, previously noticed in Knowledge in the article on "Giant Land Reptiles." From these Laramie cretaceous rocks Professor Marsh has succeeded in obtaining a quantity of teeth of mammals, although these are, unfortunately, mostly found detached. These teeth indicate mammals closely allied to *Plagiaulax* of the jurassic, and also others of a carnivorous type related to the *Amphithere*, or some of the many-molared carnivorous forms from the Dorsetshire Purbeck. Mammals of the *Triconodont* type—that is, those with the three cusps of the molars in a straight line—seem, however, by this time to have totally disappeared.

At a still later date a single tooth of the *Plagiaulax* type has been obtained from the English wealden, indicating that at that epoch the Purbeck mammals still survived in Europe, and leading to the hope that future researches will yield us further evidence of the European mammalian fauna of the wealden.

The present state of our knowledge, therefore, shows that from nearly the lowest beds of the secondary period till the close of that vast epoch, there existed a numerous fauna of small mammals distributed over a large portion of the globe, and displaying a remarkable persistence of nearly similar type. It is further evident that such of these mammals as exhibit a carnivorous type of dentition appear to be allied to the more primitive of the existing marsupials, although some of them may be more nearly related to the almost equally low insectivores. On the other hand, those which exhibit what appears to be an herbivorous modification of dental structure, if they are related to any living forms, appear to have an affinity with the modern egg-laying mammals of Australia. Now the latter, together with the marsupials and insectivores, being the lowest representatives of mammalian life at present existing, are precisely such mammals as we should naturally have expected to have been foreshadowed by more or less nearly allied forms in the secondary rocks; and, therefore, in this respect, theoretical palæontology is, so far as our present knowledge goes, precisely in accord with actual facts.

That the few triassic mammals at present known were the earliest representatives of the class cannot, however, be admitted for a moment, and we must accordingly look either to the lower triassic rocks, or to those of the underlying permian (forming the top of the palæozoic series), for the discovery of such primitive types. Should such ever be discovered, it is to be confidently expected that they will exhibit such a combination of characters common to mammals, and certain extinct reptiles and amphibians, that it will be very hard to say under what class they will have to be ranked.

Seeing that throughout the whole of the secondary period, with the possible exception of a few lowly insectivores, there is no evidence of the existence of any mammals belonging to the higher placental type (under which are included all living representatives of the class save the marsupial and egg-laying groups), the reader will naturally enquire when such higher forms first made their appearance. We answer, with the first dawn of the tertiary period; for in the very lowest eocene strata both of France and the United States there are found, side by side with small mammals allied to *Plagiaulax* and the marsupials of the jurassic and cretaceous, others, which, though still of small size, were evidently placentals. And it is very

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remarkable that this first definite appearance of the higher forms of mammalian life should, so far as we know, have been contemporaneous with the disappearance of so many gigantic types of extinct reptiles, such as the dinosaurs, the fish-lizards, and the plesiosaurs, which seem to have reached the end of their term of existence at or about the close of the secondary period.

Most of these early tertiary mammals had molar teeth carrying three cusps arranged in a triangle, like their marsupial forerunners of the secondary, from which, indeed, they were probably derived; and at this comparatively early epoch the orders of mammals were but very imperfectly differentiated from one another, it being frequently difficult to decide which were carnivores and which were ungulates. A few stages later differentiation of ordinal types, accompanied by a great increase in the bodily size of their representatives, had, however, taken place; and by the close of the eocene period, as exemplified by the higher deposits of the Paris basin, most of the present orders of mammals were well defined. Thence, through the succeeding miocene and pliocene epochs, there went on a continual evolution of mammalian life, resulting in the production of giant forms like the elephant and the rhinoceros, and also characterized by the development of specially modified types like the horse and the ox, which differ so widely from their five-toed ancestors. During the same epochs antlers were developed in the deer and horns in the rhinoceroses and oxen, while pigs and hippopotami gradually acquired the enormous tusks with which their existing representatives are armed.

Seeing, then, that it was not till the advent of the tertiary period that mammals assumed the position of the dominant forms of life, Cuvier's memorable discovery in the second decade of this century that the class dated from the middle of the secondary period has in no essential respect served to dispossess the first-named epoch from its claim to the title of the AGE OF MAMMALS.

THE NEW GEOLOGY.

By the Rev. H. N. HUTCHINSON, B.A., F.G.S., *Author of "The Story of the Hills," &c.*

A GOOD deal has lately been said about "the new geology"; perhaps a few words on this subject may not be uninteresting to readers of KNOWLEDGE. It has lately been dealt with at some length by Prof. Lapworth in his address to the Geological Section of the British Association, and by Prof. James Geikie in his address to the Geographical Section. The publication of Prof. Suess' work, *Das Antlitz der Erd* (the Crust of the Earth) a few years ago, has marked an important era in geology, and a host of new and fascinating problems are suggested by that remarkable book.

Briefly, the new geology seeks to explain the curious distribution of land and water on the globe, thus connecting together geology and geography as kindred sciences. Nor does it deal only with the present state of things; for it treats of those up and down movements of the earth's crust, whereby mountain ranges are ridged up thousands of feet above the level of the sea wherein they were formed, and the world's geographical features from time to time modified. Thus, it aims at restoring the ancient geography of former periods in the world's history, and revealing the evolution of continents. But this is not all, for, with great boldness, some of the new leaders question certain theories which, till recently, were considered to be fairly established, and have suggested new ideas which may lead to important results. Perhaps our former teachers had got more or less into a groove; and there can be no harm in trying to get out of it, so long as we do not wander hopelessly from the track.

It is true that some of the problems mentioned above have, from time to time, attracted the attention of geologists; but of late years, owing to deep sea explorations, and the elaborate study of several mountain regions, so much material has been collected that they begin to feel the ground, on which once they lightly trod, somewhat more secure. Between the years 1833 and 1852 a distinguished French geologist, M. Elie de Beaumont, put forward a theory of mountain chains which attracted a great deal of attention, and was accepted by many on account of his mathematical knowledge as well as his skill as a writer. Like the illustrious naturalist, Cuvier, he believed in periods of violence or "revolutions," with long intervals of repose between them. During the latter strata were continually deposited, but during the former mountain chains were supposed to have been formed by sudden and violent upheaval. It is needless to say that Lyell successfully dissipated this notion. Elie de Beaumont endeavoured, with great skill and learning, to show that all the mountain chains thrown up during the same revolution had one uniform direction, being parallel to each other within a few degrees of the compass, even when situated in remote regions, whilst the chains thrown up at different periods took different directions. But although this bold theory broke down, it set people thinking, and therefore served to pave the way for those who came after. Now, mountains are, as it were, the backbones of continents, and have evidently a close relation to them, determining their general directions and other features; hence, problems connected with geography, either of the present or of the past, must deal with these important features. It seems to be generally accepted that mountain ranges are wrinkles, or complicated compressed folds in the earth's crust, while the broad expanses of continents are low arches, also made up of strata, and the ocean basins are supposed to be broad troughs or inverted arches. But this seems to imply that, even in the deepest depressions of the ocean, strata exist similar to those of which continental arches are composed, a conclusion which the present writer cannot accept. We do not mean that they would necessarily be of similar composition, but that the theory implies a general similarity of structure and arrangement, so that forces affecting the continental strata in such a way as to throw them into an *upward* curve, at the same time threw those now under the ocean into a *downward* curve. The weak point in this theory, so clearly expounded by Prof. Lapworth, is that we do not know of the existence of anything like groups or series of stratified rocks on the deeper parts of the sea bed, such as we find forming the dry land of continents. According to his teaching, mountain chains, continental arches, and even the deepest oceanic troughs, are simply different parts of great groups of strata, some pushed upwards, some downwards, and some squeezed up into highly-compressed ridges to form mountain chains. Now, the continental arches and the mountain ranges are made up of the same materials, and are brought into position by the same forces; and at first sight one would conclude that the oceanic depressions must be only another phase of the same phenomena. But what if these hollows are primitive depressions on the earth's surface uncovered by strata, save for a thin layer of the "red clay," an abysmal deposit discovered of late years by soundings? In that case the continuity is broken, and the oceanic trough is no longer a continuation of the continental arch. This brings

us to the question of "the permanence of ocean basins," a doctrine that has been much discussed of late years. The more extreme advocates of this theory hold that the great oceanic depressions have, in the main, always been depressions, and therefore below sea-level, while the great land areas or continents have, in the main, been always above sea-level. They only will allow a certain amount of interchange between these two areas along the margins of the continents where soundings are shallow, and a slight elevation would make the sea bed dry land, as, for instance, the North Sea. Without binding ourselves down to this theory, we may admit that there is evidence in its favour, but perhaps it is only true for the deepest oceanic depressions.

No one has yet succeeded in showing why either the mountain chains or the broad folds of the continents and the troughs of the oceans take the directions that have somehow been given to them. The two land masses of the new world, North and South America, trend north and south, as do their mountain ranges. The Euro-Asiatic continent, on the other hand, trends east and west, as does its main axis of elevation, *i.e.*, the great chain of mountains beginning with the Pyrennees and ending with the Atlai Mountains. Why are these things so? This is a problem yet to be solved by the new geology, but at any rate it would seem that the prevailing lines of elevation have been determined at some very early period in the world's history, probably in pre-geological times.

Look at a map of the world, and you will see that the great land masses, and some of the smaller ones too, all point southwards. The most striking examples are North and South America, Greenland, Africa; but the same rule applies to Scandinavia, Spain, Italy, Albania and Greece, Arabia, India, Malacca, and even the two ends of Australia. In some cases—as, for example, Scandinavia and Italy—the reason is obvious, viz., the direction of mountain ranges. But probably several causes have combined to bring about this remarkable result. Perhaps ocean currents may be partly responsible, for in the southern hemisphere there is a decided surface drift northwards, and perhaps the currents wear away the ends of our continents.

Prof. Suess, the leader of the new school of geology in Vienna, questions the usually accepted doctrine that continents are due to elevation, and thus strikes at the root of ideas which, to most geologists, have become axioms. He considers that we have no evidence of any vertical elevation affecting wide areas such as continents, and that the only movements of elevation that take place are those by which mountains are upheaved. Most geologists believe that the sea-level has remained constant, as Lyell taught; but Suess abandons this and says that the water leaves the land, owing to changes in sea-level, instead of the land leaving the water. This is somewhat startling, and it will be interesting to see what effect such teaching will have on English geologists. In equatorial regions, according to Suess, the sea is gaining upon the land, while in other latitudes the reverse would appear to be the case. This is in harmony with his view of a periodic flux and reflux of the waters of the ocean between the equator and the poles. Another foreign geologist, Schmick, believes in grand secular movements of the ocean in order to account for apparent elevation and depression of land areas. These theories are a partial revival and development of certain old-fashioned views which, till lately, had been looked upon as quite out of date. Thus, Celsius, 150 years ago, after examining the coast lines of Sweden, came to the conclusion that the sea had retreated from the land, owing to a gradual drying up of the ocean.

But to return to the present: we find our lands distributed over the surface of a great continental plateau, the edges of which plunge down more or less steeply into the depths of the ocean, where some great depressions exist. Most geologists believe that the continental plateaux and the great oceanic depressions have never changed places. But at the same time shore lines have advanced and retreated many times, so as to bring about geographical changes of more or less magnitude, without causing a complete shifting of these two broad features. Between them there is often a kind of neutral ground which may at one time be dry land, at another, sea. Let us now consider the relation between coast lines and the slopes or margins of the great plateaux. Roughly speaking, our existing coast lines may be said to trend in the same general direction as these margins. It can be shown that there are two very distinct types of coast line, and that they are determined by the extent to which they correspond with the margins of the plateaux. First we have coast lines of a simple type, running for long distances in one general direction, and not broken up into innumerable minor features. Of such a kind are the east and west coast lines of Africa, or those of the greater part of North and South America. Now in these cases the coast lines are near to the steep slopes of the several plateaux, so that a rise of several thousands of feet would make very little change. The second type of coast line is quite different; instead of being regular, it is very irregular, nor does it run mainly in one direction. They are broken up by promontories and peninsulas, by inlets and fiords and islands. For example, we may take the coast line of north-western Europe, or the corresponding latitudes of North America. Here we have regions of comparatively recent depression which has caused the sea to come creeping over what before was land. Such regions are partially submerged lands, the surface features of which contribute to make the irregular coast lines. Thus the fiords of Norway are simply land valleys submerged, while the islands are hills partly submerged; the same applies to the west coast of Scotland. An elevation of north Europe, to the extent of 500 fathoms, would make the sea go back to the margin of the European plateaux, and give us a smooth and regular coast line about 200 miles west of the Irish coast. These irregular coast lines, then, are due to surface features of the continental plateaux, formerly made by atmospheric denudation, namely, hills and valleys. A glance at a good physical map, showing ocean contour lines, will show that they are regular and of unbroken outline, except in those shallow seas that really belong to the continental plateaux.

Finally, the coast lines of the world's continents are of very different ages; some are young, born, as it were, of yesterday, while others are of high geological antiquity. Those of the Atlantic Ocean are very ancient, while those bounding the Pacific are comparatively recent. Now this explains why the latter ocean is bounded by high mountain ranges, and the former only by low hills. These low hills are the remnants of former great mountain ranges worn down to mere stumps by ages of denudation. Thus the hills of Devonshire, Wales, Scotland, and Norway are known to be of very ancient date, and their geological structure tells us that they are mere remnants of what were once mighty ranges of mountains comparable with the Alps or the Himalayas. We also know that formerly volcanic action on a great scale took place along these old ranges; but that has died out, and they have reached a state of stability or equilibrium. Along the margins of the Pacific, however, we have a great circle of active volcanoes acting along mountain ranges of great height,

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and only recently upheaved. Time has not yet brought them low by denudation, nor have they reached a state of equilibrium between external and internal forces, so that they still manifest volcanic action. Thus we see the two types of coast line well exemplified, and these may be called the Atlantic and Pacific types.

THE FACE OF THE SKY FOR NOVEMBER.

By Herbert Sadler, F.R.A.S.

SOLAR spots and faculæ show little diminution either in number or magnitude. The following are conveniently observable minima of two Algol-type variables:—Algol, November 3rd, 11h. 51m. P.M.; 6th, 8h. 40m. P.M.; 9th, 5h. 29m. P.M.; 26th, 10h. 22m. P.M.; 29th, 7h. 12m. P.M. U Cephei, November 4th, 11h. 20m. P.M.; 9th, 11h. 0m. P.M.; 14th, 10h. 40m. P.M.; 19th, 10h. 19m. P.M.; 24th, 9h. 59m. P.M.; 29th, 9h. 39m. P.M.

Mercury is an evening star throughout November, but for the first three weeks of the month he is too near the Sun to be seen, and after that his great southern declination will prevent his being satisfactorily observed in these latitudes. He is at his greatest eastern elongation ($22\frac{3}{4}^\circ$) on the 23rd. He is at his brightest about the 30th, when he sets at 4h. 53m. P.M., or one hour after sunset, with a southern declination of $25\frac{1}{2}^\circ$, and an apparent diameter of 8·0″, $\frac{85}{100}$ths of the disc being illuminated. During the last week in the month he describes a short direct path from Ophiuchus into Sagittarius. Venus is a morning star, and though still a conspicuous object in the heavens, is rapidly dwindling in brightness. On the 1st she rises at 2h. 52m. A.M., with a northern declination of 2° 7′, and an apparent diameter of 16″, $\frac{71}{100}$ths of the disc being illuminated, and her brightness being about equal to what it was at the middle of last March. On the 16th she rises at 3h. 36m. A.M., with a southern declination of 4° 26′, and an apparent diameter of $14\frac{1}{2}$″, just three-quarters of the disc being illuminated. On the 30th she rises at 4h. 13m. A.M., with a southern declination of $10\frac{1}{2}^\circ$, and an apparent diameter of $13\frac{1}{3}$″, $\frac{79}{100}$ths of the disc being illuminated, and her brightness being about equal to what it was at the end of February last. During the month she pursues a direct path through Virgo, but without approaching any naked-eye star very closely.

Mars is an evening star, and though his brightness and apparent diameter have notably decreased, he is nevertheless better situated for observation on account of his increasing elevation above the horizon. On the 1st he rises at 2h. 5m. P.M., with a southern declination of 15° 4′, and an apparent diameter of 12·4″, the defect of illumination on the following limb being obvious. His brightness is then but little more than one-fifth of what it was at opposition. On the 16th he sets at 11h. 46m. P.M., with a southern declination of $11\frac{1}{2}^\circ$, and an apparent diameter of 10·8″. On the 30th he sets at 11h. 41m. P.M., with a southern declination of 7° $50\frac{1}{2}$′, and an apparent diameter of 9·6″, the apparent brightness of the planet being only one-eighth of what it was at opposition. During the month Mars describes a direct path through Aquarius, being very near the $4\frac{1}{2}$ magnitude star ι Aquarii on the evenings of the 3rd and 4th.

Ceres is an evening star, being in opposition to the Sun on the 15th, at a distance from the earth of about $166\frac{1}{2}$ millions of miles. She souths on the 20th at 11h. 29m. P.M., with a northern declination of 11° 46′. She will appear as a $7\frac{3}{4}$ magnitude star at the present opposition. During November she pursues a retrograde path through Taurus, but without approaching any naked-eye star. For measures of the diameter of Ceres *cf.* "Face of the Sky" for May, 1890. Vesta is also an evening star, being in opposition to the Sun on the 12th, at a distance from the earth of about 146 millions of miles. On the 20th she souths at 11h. 12m. P.M., with a northern declination of 8° 44′. She will appear as a $6\frac{3}{4}$ magnitude star at the present opposition. During November she pursues a retrograde path through Taurus to the confines of Cetus. At 10h. P.M. on the 8th she will be 6′ due north of the $5\frac{3}{4}$ magnitude star *t* 6 Tauri, and on the evening of the 15th she will be less than $\frac{1}{4}^\circ$ *n/.*, and on the 16th less than $\frac{1}{4}^\circ$ *np.*, the $3\frac{1}{2}$ magnitude star *o* Tauri. For measures of the diameter of Vesta *cf.* "Face of the Sky" for January, 1890.

Jupiter is an evening star, and is still by far the most magnificent object in the evening sky. He rises on the 1st at 3h. 24m. P.M., with a northern declination of 5° 22′, and an apparent equatorial diameter of $48\frac{1}{2}$″. On the 30th he rises at 1h. 50m. P.M., with a northern declination of 4° 37′, and an apparent equatorial diameter of $45\frac{1}{4}$″. During the month he describes a retrograde path in Pisces, being about 28′ north of the 6th magnitude star 77 Piscium (a very pretty wide pair) on the 18th, and rather over 30′ south of the 6th magnitude star 73 Piscium on the 22nd. Shortly after midnight on the 3rd a $9\frac{1}{4}$ magnitude star will be $\frac{3}{4}$′ north of the planet, and at $7\frac{1}{4}$h. P.M. on the 24th a $9\frac{1}{2}$ magnitude star will be $\frac{3}{4}$′ south of the planet. The following phenomena of the satellites occur while Jupiter is more than 8° above and the Sun more than 8° below the horizon. On the 2nd a transit ingress of the first satellite at 11h. 2m. P.M.; of its shadow at 11h. 34m. P.M.; an occultation disappearance of the second satellite at 11h. 42m. P.M. On the 3rd an occultation disappearance of the first satellite at 8h. 16m. P.M., and its reappearance from eclipse at 11h. 1m. 11s. P.M. On the 4th a transit ingress of the first satellite at 5h. 28m. P.M.; of its shadow at 6h. 3m. P.M.; a transit ingress of the second satellite at 6h. 25m. P.M., and of its shadow at 7h. 34m. P.M.; a transit egress of the first satellite at 7h. 41m. P.M., and of its shadow at 8h. 16m. P.M.; a transit egress of the second satellite at 8h. 54m. P.M., and of its shadow at 10h. 5m. P.M. On the fifth an eclipse reappearance of the first satellite at 5h. 30m. 7s. P.M. On the 6th a transit egress of the third satellite at 5h. 33m. P.M.; a transit ingress of its shadow at 5h. 57m. P.M.; a transit egress of the shadow at 8h. 12m. P.M. On the 10th an occultation disappearance of the first satellite at 10h. 2m. P.M. On the 11th a transit ingress of the first satellite at 7h. 13m. P.M., and of its shadow at 7h. 58m. P.M.; a transit ingress of the second satellite at 8h. 44m. P.M.; a transit egress of the first satellite at 9h. 26m. P.M., and of its shadow at 10h. 11m. P.M.; a transit ingress of the shadow of the second satellite at 10h. 13m. P.M., and a transit egress of the second satellite at 11h. 14m. P.M. On the 12th an eclipse reappearance of the first satellite at 7h. 25m. 42s. P.M. On the 13th a transit ingress of the third satellite at 6h. 49m. P.M.; an eclipse reappearance of the second satellite at 7h. 7m. 4s. P.M.; a transit egress of the third satellite at 8h. 59m. P.M.; a transit ingress of the shadow of the third satellite at 9h. 59m. P.M. On the 17th an occultation disappearance of the first satellite at 11h. 49m. P.M. On the 18th a transit ingress of the first satellite at 9h. 0m. P.M.; and of its shadow at 9h. 53m. P.M.; a transit ingress of the second satellite at 11h. 5m. P.M.; a transit egress of the first satellite at 11h. 13m. P.M. On the 19th an occultation disappearance of the first satellite at 6h. 16m. P.M., and its reappearance from eclipse at 9h. 21m. 22s. P.M. On the 20th an occultation disappearance of the second satellite

at 5h. 25m. P.M.; a transit egress of the first satellite at 5h. 40m. P.M., and of its shadow at 6h. 35m. P.M.; an eclipse reappearance of the second satellite at 9h. 42m. 48s. P.M.; a transit ingress of the third satellite at 10h. 15m. P.M. On the 24th an eclipse reappearance of the third satellite at 5h. 59m. 56s. P.M. On the 25th a transit ingress of the first satellite at 10h. 47m. P.M., and of its shadow at 11h. 48m. P.M. On the 26th an occultation disappearance of the first satellite at 8h. 4m. P.M., and its reappearance from eclipse at 11h. 17m. 6s. P.M. On the 27th a transit ingress of the first satellite at 5h. 14m. P.M., and of its shadow at 6h. 17m. P.M.; a transit egress of the first satellite at 7h. 28m. P.M.; an occultation disappearance of the second satellite at 7h. 47m. P.M.; a transit egress of the shadow of the first satellite at 8h. 30m. P.M. On the 28th an eclipse reappearance of the first satellite at 5h. 46m. P.M. On the 29th a transit ingress of the shadow of the second satellite at 4h. 50m. P.M.; a transit egress of the satellite itself at 5h. 12m. P.M., and of its shadow at 7h. 19m. P.M.

Saturn does not rise until 2h. 11m. A.M. on the last day of the month, but it may be mentioned that on the early morning of the 13th he will be little more than the diameter of the Moon south of γ Virginis, the star and planet appearing as a wide double star to the naked eye. Uranus is invisible.

Neptune is admirably placed for observation, rising on the 1st at 5h. 55m. P.M., with a northern declination of 20° 29′, and an apparent diameter of 2·7″. On the 30th he rises at 3h. 58m. P.M., with a northern declination of 20° 22′. During the month he describes a short retrograde path between τ and ε Tauri, to the E.N.E. of the $5\frac{3}{4}$ magnitude star Weisse's Bessel^3, iv.h. 650. A map of the small stars near the path of Neptune from November 1st, 1892, to May 1st, 1893, is given in the *English Mechanic* for October 28th.

November is a very favourable month for shooting stars. The most marked displays are the *Leonids*, on November 13th and 14th, the radiant point being in R.A. 10h. 0m., northern declination + 23°. The radiant point rises at about 10h. 15m. P.M. The *Andromedes* occur on the 27th, the radiant point being in R.A. 1h. 40m., northern declination 43°.

The Moon is full at 3h. 49m. P.M. on the 4th; enters her last quarter at 10h. 2m. A.M. on the 11th; is new at 1h. 19m. P.M. on the 19th; and enters her first quarter at 10h. 28m. A.M. on the 27th. She is in perigee at 3·9h. P.M. on the 4th (distance from the earth 221,630 miles), and in apogee at 5·1h. A.M. on the 18th (distance from the earth 252,680 miles). The greatest eastern libration takes place at 10h. 7m. P.M. on the 10th, and the greatest western at 1h. 31m. A.M. on the 27th. There will be a total eclipse of the Moon on November 4th, partly visible as a partial eclipse at Greenwich. The first contact with the penumbra is at 1h. 11·6m. P.M.; with the shadow (at 91° from the northernmost point of the Moon's limb towards the east, direct image) at 2h. 9·2m. P.M.; beginning of total phase, 3h. 23·0m. P.M.; middle of the eclipse, 3h. 45·0m. P.M.; end of total phase, 4h. 7·0m. P.M.; last contact with shadow (at 138° from the northernmost point of the Moon's limb towards the west, direct image), 5h. 20·8m. P.M.; last contact with the penumbra, 6h. 18·4m. P.M. The magnitude of the eclipse (Moon's diameter = 1), 1·092. At Greenwich the Moon does not rise till 4h. 21m. P.M., and the Sun sets at 4h. 25m. P.M. This is rather a remarkable eclipse, as the Moon attains her perigee within ten minutes of her being full and of the middle of the eclipse, and her approach to the earth is exceptionally close, the minimum distance at perigee being, according to Neison, 221,614 miles.

Chess Column.

By C. D. Locock, B.A.Oxon.

ALL COMMUNICATIONS for this column should be addressed to the "CHESS EDITOR, *Knowledge Office*," and posted before the 10th of each month.

Solution of October Problem (by G. K. Ansell) :—

1. Q to Q5; followed by 2. Q to R8, 2. Q × B, 2. Kt × B, 2. P × B, or 2. Q to Q4ch, according to Black's play.

CORRECT SOLUTIONS received from G. S. Cummings, H. S. Brandreth, and F. O. Lane.

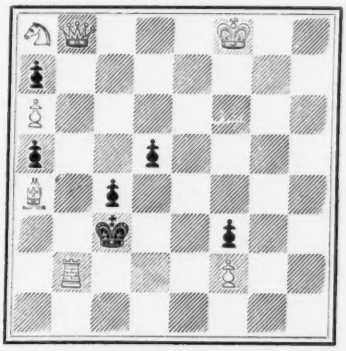
Max v. Pochhammer.—The published solution of the September problem was quite correct. What is your difficulty?

H. S. Brandreth.—Taking your question as referring to a possible solution tournament, I regret to say that the matter is not yet arranged; will give details when possible.

F. O. Lane.—Your analysis is not quite exhaustive, as you will see above.

PROBLEM.

BLACK.



WHITE.

White to play, and mate in three moves.

[This problem appeared some years ago in a French column, and seems worthy of resurrection. Mr. Steinitz admired it, and copied it in his own magazine. The composer's name has escaped our memory.]

The following is one of the most notable games played by the winner in the late Dresden tournament :—

BISHOPS' GAMBIT.

WHITE (Mr. Winawer).	BLACK (Dr. Tarrasch).
1. P to K4	1. P to K4
2. P to KB4	2. P × P
3. B to B4	3. P to Q4
4. B × P	4. Q to R5ch
5. K to Bsq	5. P to KKt4
6. KKt to B3 (*a*)	6. Q to R4
7. P to KR4	7. B to Kt2 (*b*)
8. P to Q4	8. Kt to K2
9. Kt to B3	9. P to KR3
10. K to Ktsq	10. Q to Kt3 (*c*)
11. Q to Q3	11. P to QB3
12. P to R5 (*d*)	12. Q to R2
13. B to Kt3	13. Castles
14. Kt to K2	14. B to Kt5
15. B to Q2	15. Kt to Q2
16. QB × P (*e*)	16. P × B
17. Kt × P	17. B × Kt (*f*)
18. P × B	18. QR to Qsq

19.	Q to K3 (*g*)	19. Kt to QB4 !
20.	P to B3	20. Kt × B
21.	P × Kt	21. P to R3 (*h*)
22.	KR to R2	22. KR to Ksq
23.	Kt to K2 (*i*)	23. Kt to Q4 (*j*)
24.	Q to B2	24. Kt to B2
25.	Kt to Kt3	25. Kt to K3
26.	Kt to B5	26. Kt to Kt4
27.	K to Rsq	27. K to Rsq
28.	R to Kt2 (*k*)	28. B to B3
29.	Kt to K3 (*l*)	29. Kt to K3
30.	R to Kt4	30. B to Kt4
31.	Kt to B5	31. R to KKtsq
32.	Q to R2	32. B to B3
33.	QR to KKtsq	33. R to Kt4 (*m*)
34.	P to KB4	34. R × Kt
35.	P × R	35. Q × P
36.	R(Kt)sq to Kt2 (*n*)	36. Kt to Kt2
37.	R(Kt4) to Kt3	37. Q to Kt8ch (*o*)
38.	RKtsq	38. Q to K5ch
39.	R(Ktsq) to Kt2	39. Q to Kt8ch
40.	R to Ktsq	40. Q to K5ch
41.	R(Kt3) to Kt2 (*p*)	41. R to Q4 !
42.	P to KB5	42. R × BP
43.	Q to Kt8ch	43. K to R2
44.	R to Qsq	44. R × Pch
45.	K to Ktsq	45. Q to K6ch
46.	R to B2	46. B to R5
	Resigns.	

NOTES.

(*a*) White develops his pieces in the old-fashioned order. 6. QKt to B3, and 7. P to Q4, usually precede this. The position becomes normal at the tenth move.

(*b*) Best. If 7. . . P to KR3? White may play 8. B × Pch, Q × B; 9. Kt to K5, etc.

(*c*) Considered stronger than the old continuation 10. . . . P to Kt5; 11. Kt to Ksq! P to B6; 12. P × P, or 12. B to K3 with a good game.

(*d*) Though this drives the Black Queen out of play for some time, it secures Black's advantage on the King's side, and is on that account inadvisable.

(*e*) If at all, why not on his previous move? But the delay is characteristic of Winawer's sometimes incomprehensible style, *vide* his extraordinary Ruy Lopez beginning, 1. P to K4, P to K4; 2. KKt to B3, QKt to B3; 3. B to Kt5, P to QR3; 4. B to R4, Kt to B3; 5. B × Kt (!!)—a unique instance. Instead of the unsound sacrifice in the text he should advance the QBP.

(*f*) Instead of this exchange we should prefer 17. . . QR to Qsq, threatening 18. QKt to B4. This would have adequately forestalled the threatened 18. Kt to R2.

(*g*) As this does not prevent Kt to QB4, P to B3 at once is perhaps better, and would at least give the White Queen the choice of other squares when attacked.

(*h*) Loss of time, as the Pawn cannot well be taken, *e.g.*, 21. . . KR to Ksq; 22. R × P? Kt to B4; 23. Q moves, Kt × QP, etc.

(*i*) Mr. Winawer now develops an ingenious attack. The text move is also partly defensive, to guard against the sacrifice pointed out in the previous note.

(*j*) Against the opposing array of Pawns Black's game is not easy. Dr. Tarrasch forms the admirable plan of manœuvring the Knight to KKt4, though he subsequently retires it again in favour of the Bishop.

(*k*) Better than taking the open file with the other Rook, which might conceivably be wanted elsewhere. He now threatens Kt × B and P to KB4.

(*l*) Waste of time, as his 31st move shows. 29. R to Kt4 seems preferable.

(*m*) An excellent move. The Rook exerts pressure in all directions. The sacrifice of the exchange next move is probably the quickest method of winning, and is at any rate justified by the result.

(*n*) For Black threatened, among other things, to win a Pawn by . . . Q to Q4ch. On his next move he finds himself with nothing to do.

(*o*) Black indulges in a series of checks in order to gain time. Q × BP would only complicate the game unnecessarily.

(*p*) A disastrous change of plan. This Rook is required for R3, and its removal terminates the game.

CHESS INTELLIGENCE.

The final score in the Belfast quadrangular tournament was as follows:—J. H. Blackburne, 5½, and J. Mason, 5½, bracketed first; H. E. Bird, 5, and F. J. Lee, 2. Mr. Bird was signally successful against Mr. Blackburne. Otherwise the results were in accordance with time-honoured precedents. In such company Mr. Mason is almost invariably a safe second. Mr. Lasker's absence was a matter for regret, but it guaranteed his arrival in America with a clean record.

Mr. T. H. Moore, the Hon. Secretary of the Ludgate Circus Chess Club, is endeavouring to form a Metropolitan Chess Association, and has convened a meeting of chess-players to consider his scheme. Having regard to the very large number of Chess clubs in London, the object seems a desirable one, and it is surprising that no one was found willing to undertake the task before.

A match of two games, by correspondence, played recently between the Liverpool and Glasgow Clubs, resulted in a victory for the former club, who won one game (Irregular) and drew the other (Ruy Lopez). The Liverpool players had the assistance of Mr. Burn in the earlier stages of the contest only.

Owing mainly to the efforts of Messrs. I. M. Brown and L. P. Rees, the long-discussed match between the North and South of England has now been definitely arranged. The match will take place at Birmingham early next year, probably with fifty players a side. Messrs. Owen and Wayte will captain the teams.

The annual winter tournament of the City of London Chess Club has just been started on the usual gigantic scale. There are 144 entries, and the contest may be expected to outlast the winter.

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Communications for the Editor and Books for Review should be addressed Editor, "KNOWLEDGE" Office, 326, High Holborn, W.C.